REPORT

TO THE GOVERNMENT OF CEYLON

ON THE

PEARL OYSTER FISHERIES

OF THE

GULF OF MANAAR,

BY

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WITH SUPPLEMENTARY REPORTS

UPON THE

MARINE BIOLOGY OF CEYLON,

BY OTHER NATURALISTS.

PART II.

PUBLISHED AT THE REQUEST OF THE

COLONIAL GOVERNMENT

BY

THE ROYAL SOCIETY.

LONDON:

1904.

1077

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PREFACE.

PART I. of this work was issued in November, 1903, and contained the following sections:—

(A) In the PEARL OYSTER REPORT proper: (1) the Introduction; (2) the Narrative; (3) the Description of the Pearl Banks; (4) Observations on the Sea; and (5) Observations and Experiments on the Life-History and Habits of the Pearl Oyster;

(B) In the series of SUPPLEMENTARY REPORTS: I., the Sea-bottoms; II., the Marine Algæ; III., the Gephyrea; IV., the Polyplacophora; V., the Holothurioidea; VI., the Cephalochorda; and VII., the Copepoda.

Along with that volume, I submitted to the Government of Ceylon a type-written section* dealing with practical recommendations as to the conduct of the inspections and fisheries, and as to the best means of conserving and exploiting the pearl banks. These recommendations, when revised and added to if necessary, as the result of further observation and experiments, will be given as the final section of the last volume of this Report.

In January, 1904, Mr. JAMES HORNELL was appointed Marine Biologist to the Ceylon Government, and soon after the further duties of Inspector of the Pearl Banks were added to his office. Facilities have now been given to him for carrying out the work, both experimental and executive, recommended in this Report, and he is at the present time engaged in testing the effects, under different conditions, of lifting oysters (both young and old) in bulk, by means of dredges. The transplantation of young oysters will also engage his attention, and the first results of his labours will probably be available for use before this Report is concluded.

In the present Part II., after a discussion of the past history of the principal "paars," Mr. HORNELL and I give our account of the Anatomy of the Pearl Oyster, and that is followed by a notable section on the Parasites, contributed by Mr. SHIPLEY and Mr. HORNELL.

The Entozoa of the Pearl Oyster are of practical importance from two points of view: (1) because of their effect as parasites when present in sufficient numbers to

* This has since been printed by the Government of Ceylon as a 'Sessional Paper,' Colombo, 1904.

cause lesions in the body, and (2) because some of them provide the centres of stimulation which give rise to pearl-production. The last is by far the more important, and at an early period of our work in Ceylon it engaged the attention of Mr. HORNELL and myself.

On the Cheval Paar, in March, 1902, we satisfied ourselves that the "orient" pearl, free in the tissues of the pearl oyster, is deposited around a cyst containing a Cestode larva, and preliminary notices to this effect were published in my Royal Institution lecture of March 27, 1903,* and at the Southport meeting of the British Association in September, 1903.

The Cestode larvæ were found in several stages, and the later ones, at least, clearly belonged to the genus *Tetrarhynchus*. Mr. HORNELL then found later Tetrarhynchid larvæ in the bodies of File fishes (*Balistes*) which, we were able to show, sometimes devour the pearl oysters. Finally, Mr. HORNELL's discovery at Trincomalee in November, 1903, of an adult *Tetrarhynchus* in the intestine of a Sting-ray (*Tæniura melanospilos*, BLKR.), which had freshly-swallowed *Balistes* in its stomach, led us to suppose that the Cestode which passed its youngest stage in the pearl oyster became transferred as a later larva to the File-fish and attained maturity in the Sting-ray. This view was expressed tentatively in the Introduction to Part I. and more definitely in a letter to 'Nature' of November, 1903. Mr. SHIPLEY, however, who kindly consented to collaborate with Mr. HORNELL in working up these and the other parasites for the joint report which appears in this volume, from a further microscopic examination of the specimens sent home by Mr. HORNELL, has come to the conclusion that these various larvæ differ too much in their minute characters to be placed as stages in the one life-history. He regards them as separate animals, and although it is highly probable that the sequence of hosts—Pearl-oyster, File-fish, Sting-ray—will prove to be very much as was indicated in Part I., still the pearl-producing parasite has apparently not yet been traced through all its stages to the adult condition : further field-work still lies before Mr. HORNELL.

Our original statement that the nucleus in the case of the "orient" pearls is a Cestode larva holds good, and it is interesting to find that this observation has been independently corroborated by M. G. SEURAT, working alone in his laboratory at Rikitea, in the island of Mangareva (Gambier Archipelago). The oyster on which SEURAT worked was a *Meleagrina*, and the Cestode parasite he found is, according to GIARD,† an *Acrobothrium*, or some allied form. It is possible that some of our Ceylon Pearl Oyster parasites may also belong to the genus *Acrobothrium*, although the more advanced ones are certainly Tetrarhynchids.

It is probable that Mr. SHIPLEY and Mr. HORNELL will be able to contribute a further paper on these parasites in the last volume of this Report.

* See also 'Nature' for April 30, vol. LXVII., p. 620.

† 'Comptes Rendus Soc. Biol.,' Paris, Nov. 6, 1903, vol. LV., p. 1222.

The Supplementary Reports in the present Part call for no special remark. I am greatly indebted to my friends the authors for their kindness in helping me to make these contributions to our knowledge of the Biology of the Ceylonese Seas.

Mr. ANDREW SCOTT asks me to state that *Ceylonia*, which was described as a new genus in the Report on the Copepoda (Part I., p. 265), is, he now considers, identical with CLAUS'S genus *Jurinia* ('Die Copepoden-Fauna von Nizza,' 1866). As, however, the name *Jurinia* was pre-occupied when CLAUS used it, *Ceylonia* must stand as the name of the genus. Our species from the Indian Ocean (*C. aculeata*, THOMP. and SCOTT) is distinct from CLAUS'S Mediterranean form, which now becomes *Ceylonia armata* (CLAUS).

The third volume will, so far as can be foreseen, be ready about the end of this year. It will contain Professor DENDY'S Report upon the Sponges, part of which is in type, Professor J. ARTHUR THOMSON'S Alcyonaria, Mr. E. T. BROWNE'S Medusæ, Mr. G. C. BOURNE'S Corals, Dr. EDITH PRATT'S Sarcophytons, Mr. A. SCOTT'S Ostracoda, Mr. FARRAN'S Nudibranchiata, and possibly some other papers on the remaining groups of Crustacea and Mollusca, along with further instalments of the Pearl Oyster Report by Mr. HORNELL and myself.

A fourth volume early in 1905, containing accounts of the remaining groups of animals, articles on pearl-formation and on Mr. HORNELL'S recent inspections and our final Recommendations as to the conservation of the Banks, will, it is hoped, complete the Report.

W. A. HERDMAN.

THE UNIVERSITY, LIVERPOOL,
July, 1904.

REPORT ON THE PEARL OYSTER FISHERIES OF THE GULF OF MANAAR.—PART II.

HISTORY OF THE PRINCIPAL PEARL BANKS.

It has been shown in the Introduction to Part I. of this Report (p. 4) that the thirty-six fisheries of the nineteenth century took place on nine paars only out of the possible twenty-five to thirty, which is enough in itself to suggest that these banks are of very different values economically. In the section describing the physical features of the pearl banks of the Gulf of Manaar (Part I., p. 99), a classification of the ground was made into :—

(1.) Those paars, such as the Jagerboom, Kallatidel, Aripu, and Anaivelundan, which are at present practically worthless from an economic point of view.

(2.) Some, such as the Periya Paar, which might be used as valuable sources of supply of young brood oysters for transplantation, but cannot be relied upon to yield a fishery.

(3.) Those, such as the great Cheval Paar with its various sub-divisions, the North and South Modragams, the Periya Paar Kerrai, and the Muttuvaratu Paar, which are valuable and reliable grounds upon which most of the successful fisheries of the past century have taken place.

Other paars, such as those lying off Chilaw and Karativo, are less reliable, but may be valuable on occasions; and it must be borne in mind that the whole area is possible paar-ground which might at any time become productive, and consequently the periodic inspections should never be limited to the better known regions. But, as some account has already been given in Part I. of the leading physical and biological features of all the paars, it will suffice now to direct attention to the past history, so far as it can be ascertained, of those that are really of economic importance—especially those which have yielded fisheries and are shown in the accompanying table.

THE CEYLON PEARL FISHERIES from 1801 to 1904 inclusive, showing the Banks that were fished on each occasion. (Compiled from the Government Records at Colombo.)

Cheval Paar.	North Modragam.	South Modragam.	Periya Paar Kerrai.	Periya Paar.	Kondatchi Paar.	Karativo Paar.	Muttuvaratu Paar.	Chilaw Paar.
—	—	—	—	—	1801	—	—	—
—	—	—	—	—	—	—	—	1803
1804	—	—	—	—	—	—	—	—
1806	—	—	—	—	—	—	—	—
1808	—	—	—	—	—	—	—	—
1809	—	—	—	—	—	—	—	—
1814	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1815
1816	—	—	—	—	—	—	—	—
1820	—	—	—	—	—	—	—	—
—	1828	1828	—	—	—	—	—	—
1829	—	—	—	—	—	—	—	—
1830	—	—	—	—	—	—	—	—
1831	—	—	—	—	—	—	—	—
—	—	—	—	—	—	1832‡	—	—
—	—	—	1833†	—	—	—	—	—
—	—	—	1835	—	—	—	—	—
1836	1836*	—	1836	—	—	—	—	—
1837	—	—	—	—	—	—	—	—
1855	—	—	—	—	—	—	—	—
1857	—	—	—	—	—	—	—	—
1858	—	—	—	—	—	—	—	—
1859	1859	—	—	—	—	—	—	—
—	1860	1860	—	—	—	—	—	—
1863	—	—	—	—	—	—	—	—
1874	—	—	—	—	—	—	—	—
1877	1877	—	—	—	—	—	—	—
—	—	—	—	1879	—	—	—	—
1880	—	—	—	—	—	—	—	—
1881	—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	1884
1887	1887	—	—	—	—	—	—	—
1888	1888	1888	—	—	—	—	—	—
—	—	—	—	—	—	1889	1889	—
—	—	—	—	—	—	1890	1890	—
—	—	—	—	—	—	1891	1891	—
1903	—	—	1903	—	—	—	—	—
1904	—	—	—	—	—	—	—	—
Totals: 25	7	3	4	1	1	4	3	3

* Captain DONNAN marks this fishery in his MS. chart as South Cheval Paar.

† Captain DONNAN marks this fishery in his MS. chart as North Cheval Paar.

‡ Recorded as "near the Isle of Cardien, off Karativo Island."

The greatest of these, both in extent and in value, is the Cheval Paar with its outliers, the Periya Paar Kerrai to the north-west and the two Modragams to the south-east. Next in importance is the Muttuvaratu Paar, lying off Karativo Island;

and the others to be considered here, for different reasons, are the Periya Paar, Kondatchi Paar, Karativo Paar, the Dutch Modragam, and the Chilaw group.

The accompanying sketch-map (fig. 1) shows the approximate relative positions of these, the more important paars in the Gulf of Manaar. Charts showing the topography of the region on a larger scale were given in Part I.

Fig. 1. Sketch-map showing the principal pearl-oyster banks in the Gulf of Manaar. C., Chilaw Paar; Ch., Cheval Paar; K., Dutch Modragam and Karativo Paars; M., Modragam Paars; Mu., Muttuvaratu Paar; P., Periya Paar; P.K., Periya Paar Kerrai.

I. CHEVAL PAAR.*

The map published by Baldæus in 1672 shows, from the relative positions of prominent features of the shore-line, that the pearl banks then fished off Aripu correspond with the Cheval Paar of the present day. This establishes the permanence of the Cheval Paar in its general position and outline for over two centuries, and we have native records of important pearl banks in that region from much earlier times. No doubt, over-washes of sand have, from time to time, obliterated portions of the oyster-bearing ground, and at other times the scouring action of tides and storms may have extended the area of the hard "paar"; but notwithstanding these vicissitudes, we still have, as in early Sinhalese times, a group of more or less continuous banks

* For an account of the leading physical and biological characters of the Cheval Paar, see Part I., p. 100.

lying off Aripu, in the centre of the bight of Kondatchi, and yielding the most important fisheries now as they did in the days of the Tamil Queen Alliyarasani. The list of the fisheries given on p. 2 shows that the Cheval has given as many fisheries as those of all the other paars together.

There is some uncertainty in regard to the early records of the nineteenth century. The Cheval and Modragam banks are apparently sometimes entered as the Aripu paars or the paars off Aripu; the subdivisions, such as North Cheval, South-East Cheval, &c., have not a uniform nomenclature in the reports of different Inspectors, and the Government records do not agree in all respects with Captain DONNAN's MSS. and charts to which we have had access. These discrepancies do not affect, however, any important points from which conclusions are drawn in this Report.

RECORD* OF THE CHEVAL PAAR.

Mar., 1802.—Whole Cheval covered with oysters 4 to 5 years old.

Oct., 1802.—Sample of 1668 oysters $5\frac{1}{2}$ to 6 years old lifted.

Mar., 1804.—Fishery (yielded 770,202 rupees).

,, 1805.—Oysters 5 to 6 years old on east side. Sample lifted.

,, 1806.—Fishery (yielded 412,842 rupees).

,, 1808.— ,, ,, 842,577 ,,

,, 1809.— ,, ,, 272,463 ,,

Oct., 1809.—Very few oysters on Aripu Paar and on Cheval, 6 fathoms. On South-east Cheval oysters 6 to 7 years old. On the North, 6 fathoms, 10 to 70 oysters at a dive. On the South, 7 fathoms, young oysters 2 years old. In 6 fathoms, on Koddai Paar (west end of South Cheval), oysters 1 year old. On the south-west, in 9 fathoms, oysters 3 years old.

Nov., 1810.—Oysters 2 to 4 years old of "Koddai" and "Cheval" kind. On South and South-west Cheval abundance of oysters 2 to 4 years old. On the north end, a very small spot, 5 to 6 years old. Sample lifted.

,, 1811.—Oysters 4 to 5 years old on East Cheval. A few 1 year old on the north-east side of the Aripu Paar. Abundant, 3 to 4 years old, on North-east Cheval. On West Cheval abundant oysters of "Kottapakku" variety. Pearls from 943 oysters valued at Rs. 8.93.

Mar., 1813.—On the South-east Cheval oysters 5 to 6 years old, in 6 fathoms, and a great proportion 6 to 7 years old, with many dead shells. The bank measures 2 × 2 miles and should be ready for fishing in Mar., 1814. On the East Cheval abundant oysters 6 years old. On the North-east Cheval, on a bank measuring 2 × 1 miles, abundant oysters 5 and 6 years old and

* Condensed from all the records at our disposal—Inspectors' reports and other papers by Captain DONNAN, Sir WILLIAM TWYNAM, and others, MSS. and charts in the Government Offices at Colombo, and other information obtained by Mr. HORNELL and myself.

some dead shells (supposed to be the same oysters as those found on the Periya Paar Kerrai in 1810).

Oct., 1813.—Samples lifted from Koddai Paar 6 and 7 years old, and from Kottapakku Paar 5, 6, and 7 years old, and from South-east and North-east Cheval 7 years old.

Mar., 1814.—Large fishery (yielded over 1,000,000 rupees to Government).

Oct., 1815.—Very few oysters, 1 year old, on Koddai Paar (centre of Cheval). On Kottapakku Paar (west of Cheval) oysters 6 years old, and some on North-east Cheval; both the latter recommended for fishery.

Mar., 1816.—All oysters dead. No fishery except a few from Kallatidel Paar. [Small fishery on Cheval and Modragam, *fide* VANE.]

,, 1820.—Oysters 4 years old fished (yielded 30,410 rupees).

,, 1821.—Remainder dead.

,, 1826.—Abundant oysters too young for pearls.

Oct., 1826.—5 year old oysters and smaller ones.

Mar., 1829.—Fishery on North-west Cheval (yielded 382,737 rupees).

,, 1830.— ,, South-east ,, ,, 222,564 ,,

Oct., 1830.—Sample lifted.

Mar., 1831.—Fishery on North-west Cheval (yielded 293,366 rupees).

Nov., 1834.—Oysters in 7 fathoms.

Mar., 1835.—Oysters 4 and 4½ years old, recommended for fishing next March. Part of Cheval fished, along with Periya Paar Kerrai.

,, 1836.—Fishery on Central Cheval and Koddai Paar (South Cheval) (yielded over 160,000 rupees).

,, 1837.—Fishery on North Cheval (yielded 106,312 rupees).

Nov., 1840.—Oysters 1½ to 3 years old.

,, 1851.— ,, 1 year old, on South-west Cheval, in a healthy state.

Mar., 1853.—Large bed of oysters on South-west Cheval (2 × 1 miles). Oysters "4 or 5 years old."

,, 1854.—Oysters on South-west Cheval healthy, but scattered and not very plentiful.

Nov., 1854.—Sample taken up from South-west Cheval and fishery recommended. Younger oysters 1½ to 2½ years old found to the west.

Mar., 1855.—South-west Cheval fished (yielded 109,220 rupees).

,, 1856.—Oysters on northern part remaining from last year said to be 5½ years old. Oysters 3 years old to south.

,, 1857.—North-west Cheval fished (rather too young, over 32,000,000 oysters yielded only 203,633 rupees).

Nov., 1857.—Many dead shells.

Mar., 1858.—North-west Cheval fished (over 16,000,000 oysters yielded 241,200 rupees).

Nov., 1858.—Oysters 6 months old all over Cheval.

Mar., 1859.—North-west Cheval fished (3,000,000 oysters yielded 194,481 rupees). Oysters 2 years old on South-east Cheval. Oysters 1 year old on South-west Cheval.

Nov., 1860.—Abundant oysters 3 years old on South-west Cheval.

,, 1861.—Sample from South-east Cheval taken up and estimated at 5 years. Considered too young to fish next year [!].

Mar., 1862.—Oysters plentiful, but many dead shells to south.

Nov., 1862.—South-east Cheval inspected and sample lifted. Oysters fine and healthy looking and full grown. On the north-east the oysters lie thick and healthy, but are younger than on the south-east.

Mar., 1863.—South-east Cheval fished (over 11,000,000 yielded 510,178 rupees), oysters dying off. Oysters on South-west Cheval. Ground covered with large fishes (Ray) when fishery began.

Oct., 1863.—Sample lifted from South-west Cheval and fishery recommended for March next; many dead shells found. The oysters are of the same brood as those fished in March, 1863. No young oysters on any part of Cheval.

Mar., 1864.—All dead. Possibly some eaten by Rays, but the oysters were old.

Nov., 1865.—Bare of oysters.

Mar., 1866.—No oysters.

,, 1867.—Abundant young oysters (? "false-spat," *fide* HORNELL) attached to weed on grounds fished in 1858, 1859, and 1863, but only weed on fishing grounds of 1864 and 1859.

Dec., 1868.—Weed and oysters gone. No young ones. North and north-east much covered with sand. South-west and south (Koddai Paar) clear of sand, but covered with sponge.

Oct., 1869.—No oysters on usual grounds, but a patch 2 or 3 years old to eastward. Not enough to fish.

Mar., 1870. Oysters still there. 9 patches of young oysters 1 to 3 months old on Cheval. To west nothing but sand and rock.

April, 1871.—Two patches 1 year old on south-west and north-west. A few oysters 4 years old on patch found in 1869.

Mar., 1872.—Bed of oysters 2 to 3 years old from south-west to north-west. None on south-east.

,, 1873.—Oysters in same position as last year. Patch of young oysters a month or two old to extreme north-west.

Dec., 1873.—Oysters have begun to die off. Small fishery recommended for next March. Valuation Rs. 33.33 per thousand. Young oysters to north-west have all disappeared.

Mar., 1874.—North-west Cheval fished (yielded 101,199 rupees). Extensive

deposit of young oysters on South-west and South-east Cheval, extending to south part of Modragam.

Mar., 1875.—Large bed of about 10,000,000 healthy oysters, 2 years old, on South-east Cheval. Smaller bed to east, believed to be of same age. On ground fished last year very few oysters and 40 per cent. dead shells.

,, 1876.—On South-east Cheval a few oysters scattered over a large area. Patch to the eastward now joined on. Very few dead shells. On West and North-west Cheval a very large number of small oysters 6 months old. Rock-fish [*Balistes*] eating the oysters.

Nov., 1876.—On South-east Cheval a bed of 3,000,000 oysters and some dead shells. Pearls valued at Rs. 26.70 per thousand. Oysters supposed to be 4 years old. Fishery recommended for next March. Young oysters on West and North-west Cheval still abundant.

Feb., 1877.—Oysters dying out.

Mar., 1877.—Fishery on East and South-east Cheval (yielded 184,591 rupees).

,, 1878.—Large bed, 3 × 1½ miles, of 3-year old oysters, thickly spread and firmly attached. Those on the south half are the oldest and should be fished first. To the south-east a small bed of oysters 9 months old. A small patch left over from fishery on East Cheval seemed healthy, and the pearls were more valuable than last year.

Nov., 1878.—Oysters still abundant, but not grown much.

,, 1879.—Bed of about 66,000,000 oysters 4½ years old, extending about 3 miles north-north-west and south-south-east, including the portions fished in 1831, 1835, 1855, 1857, 1858, 1859, 1874, and that which failed in 1864. These oysters seem to require another year. They are mixed with younger ones, probably from the patch found in 1878 to the south-east, which had disappeared. On the South-east Cheval 1 square mile was covered with oysters 3 months old, firmly attached. Samples from the south-east of the bed of older oysters were valued at Rs. 9.39 per thousand, and those from the north-west at Rs. 6.43. The south-east portion of this bed is recommended for fishing, as there are so many oysters.

Mar., 1880.—Fishery on North-west Cheval (over 35,000,000 oysters yielded only 200,152 rupees).

Dec., 1880.—On the North-west Cheval an extensive bed of 58,000,000 oysters 5½ years old. Valuation Rs. 21.37 per thousand. Immense numbers of young oysters, 3 months old, on bed fished last season, but the young oysters on the south-east, referred to in report of 1879, are dying off.

Mar., 1881.—Splendid fishery on North-west Cheval Paar (27,000,000 oysters yielded 599,533 rupees), but in lifting sample in February before the fishery the oysters were found to have thinned 40 per cent. since November.

Mar., 1882.—No oysters on banks off Aripu.

,, 1883.—No oysters.

,, 1884.—Oysters about 3 months old on East and West Cheval.

,, 1885.—East and West Cheval covered with a most extensive deposit of young oysters 18 months old. Shoals of Rays were seen, but have apparently done no damage.

,, 1886.—Large beds on east and west flourishing. Oysters $2\frac{1}{2}$ years old. On the east 202,000,000 and on the west 79,000,000. Loss since last inspection probably due to overcrowding. No damage seems due to Rays.

,, 1887.—Oysters $3\frac{1}{2}$ years old—healthy. On east side 195,000,000. On west side 38,000,000 and dead shells apparently destroyed by Rays. North-east Cheval fished (yielded 292,430 rupees).

Nov., 1887.—Extensive beds of oysters, 4 years old, all over. On west side the old oysters are covered with young ones 3 months old.

Feb., 1888.—Nearly all the old oysters gone from the bank. Possibly caused by currents. But found and fished to the east of the East Cheval (22,000,000 oysters yielded 804,247 rupees). West side stocked with young oysters.

Nov., 1888.—A few old oysters on the east. Young about 15 months old on west. Many dead shells.

,, 1889.—On the West Cheval a thick deposit of young oysters 3 months old. Those found in the same place in November, 1888, are all gone. None on the East Cheval.

,, 1890.—Four patches of oysters 15 months old on west and south.

Mar., 1892.—Bank bare of oysters.

,, 1893.—West side well stocked with oysters, 6 months old, in detached patches. A few small patches on north-east.

,, 1894.—Bare of oysters.

,, 1895.— ,, ,,

,, 1896.—Small patch of oysters, 6 months old, on north-west.

,, 1897.—Bare of oysters.

,, 1898.—A few small patches of oysters, 3 to 6 months old, on south-east.

,, 1899.—The few patches of young oysters found last year on East Cheval have entirely disappeared.

,, 1900.—Very extensive bed of oysters, 3 to 9 months old, on West Cheval 3 small patches of similar oysters on east side.

,, 1901.—Three detached beds on West Cheval. 2 detached beds, $1\frac{1}{2}$ to 2 years old, on East Cheval.

Oct., 1901.—Oysters in abundance, $1\frac{1}{2}$ to 3 years old, on both East and West Chevals, also spat up to 4 months old on North-east Cheval.

Mar., 1902.—Both old (3 years) and young (3 to 6 months) oysters on both East and West Chevals, and also some in the Central area.

Nov., 1902.—Both old (over 3 years) and young (6 to 18 months) oysters abundant on both East and West Chevals. Samples taken.

Mar., 1903.—Fishery on East Cheval (about 46,000,000 oysters, including Periya Paar Kerrai, yielded over 800,000 rupees).

Feb., 1904.—Mr. HORNELL estimated there were 35,000,000 of $4\frac{1}{2}$-year old oysters on the West Cheval. Also many young, about $2\frac{1}{2}$ years old.

Mar., 1904.—Fishery on West Cheval (over 41,000,000 oysters yielded over 1,000,000 rupees).

On looking over this record, although it is obvious that it is incomplete, that some gaps (*e.g.*, 1840 to 1851) occur, that some oysters are mentioned whose first appearance was not noted and others whose fate is not known, still it is possible, in most cases, to trace the history of events and to follow particular broods from year to year. One cannot but feel doubtful as to the accuracy of some of the ages assigned, especially in the case of the earlier records. If the oysters estimated at 5 to 6 years old in March, 1805, were those fished a year later, they must then have been unusually aged. Captain DONNAN considers that most oysters when fished are not more than 5 years old, and I am inclined to agree with him. If the 1805 oysters were really upwards of 5 years, a very serious risk was run in leaving them unfished; and the same remark applies in regard to the oysters estimated at 6 to 7 years in March, 1813, and fished in 1814. It is probable, looking through these and other records, that many beds of oysters have been lost in the past through delay in fishing. Inspectors and Administrators are no doubt tempted to wait by the thought that the older the oysters are the more valuable will be their pearls. An additional year of growth no doubt increases the value greatly, but the chances of death in that final year are also greatly increased. On the whole I am of opinion that 5-year old oysters should never be left unfished. It will be noticed that the reputed 6-year old oysters of October, 1815, apparently died that winter, that the 4-year old oysters of March, 1820, were dead before the following year, that oysters probably 4 years old in December, 1873, had begun to die off, that oysters supposed to be 4 years old in November, 1876, were dying 3 months later, and that the oysters fished on South-East Cheval in March, 1863 (which according to the estimate were 7 years! but I suspect this to be a mistake and that they were not more than 5 years) were dying off, while those of the same brood from the South-west Cheval were found to be all dead in March, 1864. I think it probable that these oysters of the 1863 fishery were those found "6 months old all over Cheval" in November, 1858, and were therefore about 5 years old when fished. If I am right in this estimate, then the "5 years" entered under November, 1861, must be a mistake for 3 years, and in that case the absurdity of the remark "considered too young to fish next year" disappears.

Considering the large number of broods of oysters that have succeeded one another

on the Cheval Paar, the catastrophes have been singularly few, and this is important testimony to the reliability and relative safety of this region as a rearing ground, provided it is kept supplied with the necessary young oysters. Omitting those batches which probably died off from being left too long unfished, the only evidence we have of catastrophic disappearances is as follows :—

(1.) Young oysters attached to weed in March, 1867, gone in December, 1868. (Probably due to overwash of sand; but the young spat when attached to weed must always be very uncertain, and may simply have drifted out of the area when the weed rotted or was detached by the next monsoon. Mr. HORNELL has suggested that these were "false spat"—*Avicula vexillum.*)

(2.) The 2 to 3-year old oysters which were greatly diminished in number between March, 1875, and March, 1876. (Probably eaten by carnivorous fishes, such as *Balistes.*)

(3.) The extensive beds of oysters 4 years old in November, 1887, which had nearly all gone in February, but which are said to have been found further to the east during the fishery. (This was no doubt due to currents during the north-east monsoon,* as suggested by Sir WILLIAM TWYNAM.)

(4.) A few patches of small oysters found on East Cheval in 1898 had disappeared in 1899. (Small patches may easily be missed; or the ravages of a few *Trygon*-rays or a shoal of *Balistes* may so far reduce the patch that it is no longer recognisable by a few chance dives. I think it unlikely that muddy water caused by floods in the four rivers of the adjoining coast could, as suggested by Sir W. TWYNAM, produce a serious effect so far out at sea. The winter of 1898–9 was, however, an exceptional one, with heavy rains and strong currents.)

* This is corroborated by Captain DONNAN, who has kindly read the proofs of this section of the Report for me, and who writes (July 22nd, 1904): "I have no doubt whatever that a strong south-south-east current was the cause of the loss of the splendid bed of oysters on the Cheval in 1888. I noticed when I visited the bank in February to lift a sample and buoy off the bank, that the pieces of rock brought up by the divers were covered with byssus, and the divers said no shells, broken or whole, were to be found. I therefore concluded that the oysters must have been swept away by a current. I then asked the man in charge of the "Active," which was on the paar from November as a guard boat, if he had noticed any current after I left the banks in November, and he said, yes, in December when at anchor on the bank he found the current so strong to the south that he was afraid the guard-boat would drag her anchor, and he let go a second anchor—he estimated the current to be running at 4 knots and said it lasted a week. During my inspection of the bank in February, the divers brought up a *Pinna* shell with a number of old oysters on it, and so to try the effect of a current, I had the shell towed alongside the tug "Active," going at a speed of 4 knots. After about an hour's towing, and finding that none of the oysters had dropped off the shell, I had the speed increased to about 5 or 5½ knots, and in about half an hour's time all the oysters had dropped off, leaving their byssus on the *Pinna*; so after that experiment I had no doubt about a current being the cause of the loss of oysters from the Cheval."

None of these cases of disappearance ot oysters present any special difficulty or remain in mystery. All can be accounted for by natural causes which we know to be at work.

As the Cheval Paar is then, under most circumstances, so reliable as a rearing ground, it is important to consider the adequacy of the supply of spat. On looking over the history, we find that there is either direct record or indirect evidence of at least 26 fresh broods of oysters having arisen during the nineteenth century, as follows :—

Spat of 1801 (?).—Fished 1806.
,, 1805 or 1806.—(?) Fished 1809.
,, 1807.—Sampled 1811.
,, 1808.—Fished 1814.
,, 1810.—Fished 1816.
,, 1816.—Died 1821.
,, 1824 or 1825.—Fished 1829, 1830, and 1831.
,, 1831.—Fished 1835, 1836, and 1837.
,, 1838.—No record between 1840 and 1851.
,, 1850.—Fished 1855.
,, 1852.—Fished 1857 and 1858.
,, 1853.—Fished 1859.
,, 1858.—Fished 1863 ; remainder dead 1864.
,, 1867.—Spat on weed disappeared next year.
,, 1870.—Fished 1874.
,, 1873.—Fished 1877.
,, 1875.—Fished 1880 and 1881.
,, 1877.—(?) Fished also in 1881.
,, 1879. } Young oysters which died off.
,, 1880. }
,, 1883.—Fished 1887 and 1888.
,, 1887.—Young oysters which died off.
,, 1889.—No record of these.
,, 1892.—No record of these.
,, 1898.—Young oysters which died off.
,, 1899.—Fished 1903 and 1904.
[,, 1901.—Not yet fished.]

That 26 deposits of spat should have produced 25 fisheries must be considered a good record, and a strong testimony to the economic value and reliability of the bank. Several of the broods, such as that of 1899, have produced more than one fishery; and, on the other hand, some few broods evidently died off at an early age or have remained unrecorded. Although there have been so many fisheries, 25 in a century,

and although it takes 4 or 5 years of oyster growth to produce a fishery, still it must not be supposed that the whole of the ground was almost continuously occupied by these successive broods of oysters. The area is so large and varied, and so small a space covered with spat is sufficient to produce later on a fishery, which itself may occupy only a small portion of the paar (see fig. 3), that there must often have been wide extents of ground uncovered. There is room on the Cheval Paar for many beds of oysters of several different ages to flourish simultaneously. It is probably a very rare occurrence for the whole region to be naturally covered by oysters young or old, and it is this that affords a valuable opportunity for artificial operations. If young oysters can be obtained from other less reliable paars, the rearing ground of the Cheval ought never in the future to be left unoccupied. As soon as possible after an area has been cleared by a fishery, it ought to be re-stocked by young oysters transplanted from the Periya or other outlying paars, so as to keep up, if possible, a constant series of broods coming to maturity in succession.

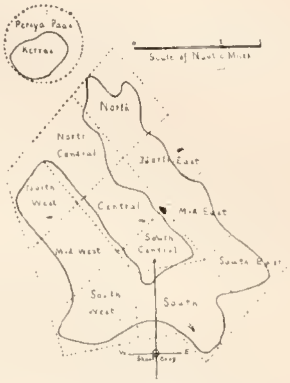


Fig. 2. Proposed culture areas recommended for the Cheval Paar and Periya Paar Kerrai.

In the following table the fisheries, since the beginning of the nineteenth century, have been assigned to their respective subdivisions of the Cheval, and it must be remembered that each of these is an area of at most perhaps a couple of square miles, capable of containing many millions of oysters and of yielding a profitable fishery. Yet several, if not most of these subdivisions, have lain either wholly or in part vacant in most years, and therefore, profitable as the Cheval Paar has been, there can be little doubt but that by such a system of cultivation as was outlined in Part I. of this Report, and will be elaborated in detail in the Final Recommendations, it could be rendered more profitable still. The diagram (fig. 2), planned by Mr. Hornell, shows the relative positions and names of the subdivisions referred to. These we would propose as culture areas, nearly all of which might be extended and improved by—

(1) Dredging up and removing injurious and competing organisms, and

(2) Laying down suitable clean hard materials such as broken tiles and stone, dead coral and shells as culch, to give a foothold to the oysters.

TABLE OF THE SUBDIVISIONS OF THE CHEVAL PAAR WHICH HAVE YIELDED FISHERIES.

The Nomenclature of the Subdivisions is that given in fig. 2.

		Totals.
Region undefined	1804, 1806, 1808, 1809, 1814, 1816, 1820	7
North Cheval	1833, 1835, 1887, 1903	4
North-east Cheval. . . .	1887, 1888, 1903	3
Mid East Cheval	1837, 1888, 1903	3
South-east Cheval. . . .	1877, 1888, 1903	3
South Cheval	1829, 1830, 1836, 1837, 1858, 1863, 1877, 1888	8
South-west Cheval . . .	1855, 1863, 1888, 1904	4
Mid West Cheval	1831, 1835, 1859, 1874, 1880, 1888, 1904	7
North-west Cheval . . .	1833, 1835, 1881, 1888, 1904	5
North Central Cheval . .	1833, 1835, 1857	3
Central Cheval.	1835, 1836, 1857, 1859, 1888	5
South Central Cheval . .	—	Nil

The localities of a number of the earlier fisheries of the Nineteenth Century (1828 to 1863) on the Cheval Paar and its extensions to north and south, the Periya Paar Kerrai and two Modragams, are shown on fig. 3. The exact positions of the fisheries before this time are not known with certainty. The next fishery after these dates (that of 1874) will be shown in a separate diagram, and a series of still later fisheries and inspections showing the distribution of oysters over the Cheval area will be discussed below. It will be noted from this diagram (fig. 3) how irregular and comparatively small the areas covered by a fishery usually are; and how wide extents of the paar may be left unoccupied by oysters. It is also clear from this figure that fisheries, and therefore beds of oysters, are by no means limited by the conventional

U-shaped outline of the Cheval Paar. The central embayment has evidently been sometimes occupied by oysters in the past just as it was when we dredged across it in February and in March, 1902. The position of the Periya Paar Kerrai as a northern extension of the East Cheval, and the practical continuity of the Modragams with the south central region are evident from both the plan of the ground and the distribution of the fisheries.

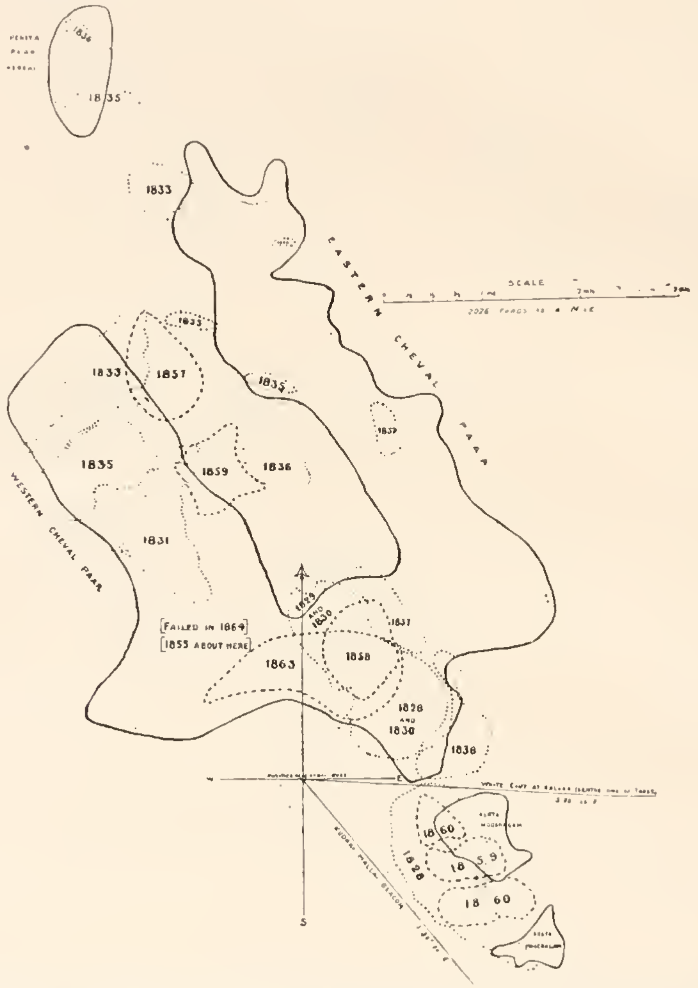


Fig. 3. Plan of the pearl fisheries, from 1828 to 1863, on the Cheval Paar, the Modragams, and the Periya Paar Kerrai.

The next fishery after 1863 is that of 1874, which took place on the North-west Cheval Paar, and as we have very complete records and charts showing the history of this bed of oysters, from the time when it was deposited as spat onwards to the fishery, these have been combined to form the diagram (fig. 4). This shows, by different lines, the condition during the five years 1870 to 1874, and may be taken as an example of the normal uneventful development of a small bed of oysters. It shows what are probably very usual features, viz. :—(1) that small isolated patches

of spat either disappear (as in the case of those marked 1, 4, and 6) or expand and join (as in the case of 2, 3, and 5) to form eventually a continuous bed; (2) that if all goes well, as the oysters grow older they increase, for a time, their area of distribution, *e.g.*, we have the two beds of 1871 joining and expanding to form the much larger area of 1872, which again increases somewhat in 1873; (3) after a time, however, the oysters, now over 3 years old, begin to die off, and shrinkage of the bed

Fig. 4. History of one generation of pearl oysters on the West Cheval Paar—from the fall of "spat" in 1870 to the fishery of 1874.

takes place, so that the area fished in 1874 is considerably smaller than that occupied in 1873 or in 1872, and is no larger than the two beds of young oysters present in 1871. In accounting for such changes in the position and the extent of the bed, it is necessary to bear in mind (1) the very considerable powers of locomotion, especially of the young oyster, and (2) the damage done to a bed by both animate and inanimate foes. These have already been discussed in Part I. of this Report.

In order to illustrate more fully the irregular distribution of the oysters on the ground, the large areas that may remain unoccupied on a paar and the changes that take place during the development of a deposit of spat into a fishable bed of oysters, we shall now give a series of diagrams compiled from the MS. notes and plans of the periodic inspections deposited in the Master Attendant's Office at Colombo. They deal with the last 20 years, from March, 1884, and show (figs. 5 and 6) an extensive bed of young oysters which yielded fisheries in 1887 and 1888, various scattered deposits of young oysters (figs. 7 and 8) which apparently came to nothing, and finally (figs. 9 to 14) the detailed history of the extensive bed of young oysters which was first seen on the Western and Southern Cheval in March, 1900, afterwards spread on to the East, and eventually gave rise to the two recent very important fisheries, on the East Cheval in 1903 and on the West in 1904. Although these last oysters

must all have been of much the same age, those on the East Cheval, and especially on the North-east, seem to have grown larger and looked older than the others. They were the first to be fished. Figs. 11 to 14 also show the rise and growth of the young oysters, now between 2 and 3 years old, which will probably provide a fishery in 1905 or 1906. In addition to the areas shown on the Eastern Cheval, they also occupy considerable parts of the South, Central, and Western. There are, as yet, no younger oysters in the district.

The first set of diagrams (figs. 5–8) shows the condition of the Cheval Paar at the inspections from March, 1884, to March, 1893. The continuous thick line represents the outline of the paar in each case. In fig. 5 the dotted area represents the part covered with oysters about 3 months old in March, 1884, and the area enclosed by a broken line shows the position of these same oysters in March, 1885. The shrinkage seen in the south-west corner becomes more marked in the following year.

In fig. 6 the dotted area is that occupied by $2\frac{1}{2}$-year old oysters in March, 1886, and the broken line shows the distribution of the same oysters in March, 1887 (then $3\frac{1}{2}$ years old). The oysters now formed two distinct beds, corresponding roughly with the East and West Cheval. These oysters were fished in March, 1887, and March, 1888, and, although so young, yielded a good return.

In fig. 7 the dotted areas on the Western Cheval represent two patches of young oysters, and that on the Eastern Cheval some scattered mature ones in November, 1888 (left over from the fishery in March): the broken line encloses an area covered with oysters 3 months old in November, 1889, while the four black patches show the parts covered with oysters 15 months old in November, 1890. None of these survived to March, 1892, when the bank was found quite bare of pearl oysters.

In fig. 8 the black areas show the extent of ground covered by young oysters, 6 to 9 months old, in March 1893. These scattered deposits came to nothing, as the bank was found to be bare of oysters at the inspections of 1894 and 1895.

The following six diagrams (figs. 9 to 14) show the distribution of oysters on the Cheval Paar during the period March, 1896, to April, 1903, as shown by the periodic inspections and the fishery of 1903. The conventional outline of the bank is shown as a continuous thick line. In fig. 9 the area with oblique lines was covered with oysters 6 months old in March, 1896, the small black areas were occupied with oysters 3 to 6 months old in March, 1898, and the areas enclosed by a dotted line (including an extent of about 5800 acres, occupying the greater part of the West and South Cheval) indicate young oysters at the inspection of March, 1900. These must have appeared as spat after the inspection of 1899, and are of interest as giving rise to the very important fisheries of 1903 and 1904. The bank was bare of oysters at the inspections of 1894, 1895, 1897, and 1899.

In fig. 10 the black areas show the distribution of oysters from $1\frac{1}{4}$ to $1\frac{3}{4}$ years old at the inspection of March, 1901, the dotted circles in this and subsequent figures showing the areas which were surveyed.

Fig. 5.

Fig. 6.

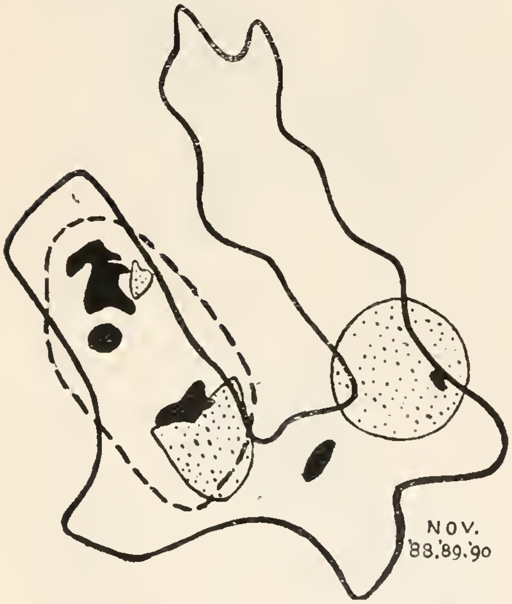


Fig. 7.

Fig. 8.

Figs. 5 to 8. Diagrams showing the distribution of oysters on the Cheval Paar at the inspections from March, 1884, to March, 1903. Scale about half an inch to one nautical mile.

Figs. 9 to 14, on p. 19, show a similar series of diagrams for the period March, 1896, to the end of the recent fishery in 1903.

Figs. 11, 12, 13, and 14 represent the condition of the paar at the inspections of March, 1902, November, 1902, February, 1903, and immediately after the fishery of 1903 respectively, the black areas showing the distribution of the same oysters as those shown in fig. 10, and the dotted areas showing the distribution of a new brood of young oysters, 3 to 6 months old, in March, 1902, and their condition at subsequent inspections. In fig. 13 the obliquely shaded areas represent continuations of the black areas outside the parts actually surveyed, which were only discovered by the divers at the fishery. In figs. 12, 13, and 14 the parts outside the dotted circles were not inspected. The Western Cheval was still covered with the oysters which have just been fished in March, 1904.

Fig. 14 is of interest as showing the very considerable area covered by fishable oysters (estimated at 22,000,000) which the divers had failed to clear in the fishery of 1903.

The history of the recent fishery (April, 1904) shows the reliable character of the Cheval Paar. Mr. HORNELL, in February, found the three western beds of oysters in practically the same positions they occupied when we surveyed them with Captain DONNAN in March, 1902. It is therefore only under some exceptional circumstances that any catastrophe happens to a bed of oysters on the Cheval.

The general conclusions we arrive at in regard to this ground are :—

1. That the Cheval Paar provides most favourable conditions for future fisheries, provided there be a sufficient deposit of spat.
2. That such deposits of spat are unfortunately of comparatively rare occurrence, and this accounts for most of the blank years in the history of the fisheries.
3. That consequently the need arises for transplanting young oysters from elsewhere on a large scale if such blank years on the Cheval Paar are to be avoided.

Consider, for example, the position of affairs at present and in the immediate future. The recent fishery (1904) has probably cleared the Cheval Paar of all fishable oysters, except what may still remain on the East Cheval from the fishery of 1903. The next oysters to come on are those on the West and parts of the South Cheval, which are now in their third year, and which will, if all goes well, yield a fishery in 1905 and, perhaps, also in 1906. There are no younger oysters in the Cheval district. There has been no fall of spat this year as yet, and the next possible time when it might occur will be about December. Taking the most favourable estimate, such oysters would not be fishable until March, 1908, but it may very possibly be that no deposit of spat will take place this year, and that consequently future fisheries, if left to unaided nature, may be still further delayed. There are, however, now plenty of oysters about 6 months old on the Periya Paar. They cover an area of about 10 square miles, and are probably sufficient to stock the Cheval Paar several times over. The past history of the Periya Paar justifies us in saying that there is

Fig. 9.

Fig. 10.

Fig. 11.

Fig. 12.

Fig. 13.

Fig. 14.

practically no chance of these young oysters coming to maturity where they are. If these are transplanted to the Cheval banks at the earliest opportunity and in sufficient quantities—for such work to be successful must be done on a large scale—they ought to be in their fourth year by March, 1907, and would probably yield fisheries then and in 1908. Our aim should be to have a constant succession of broods maturing on the Cheval, so as to give a continuous series of fisheries, and if sufficient spat does not fall naturally, these broods must be brought from elsewhere.

II. MODRAGAM PAARS (NORTH AND SOUTH).

Fig. 3, on p. 14, shows the close relation between the two little Modragam paars and the great Cheval region. An account of the leading physical and biological characters will be found in Part I., p. 105. The fishery record is as follows :—

1804.—Fished along with the Cheval Paar.

Oct., 1804.—Oysters 5 years old on a bank of small extent.

Mar., 1805.—Small bed of oysters 6 years old. Sample of 1987 oysters lifted. To the south of the bank was found a patch of "Kottapakku" oysters, 3 to 4 years old, and another patch of same age and kind to the north-east. Also a patch of Cheval oysters, 3 to 4 years old.

1806.—Fished along with the Cheval Paar.

1808.— ,, ,, ,, ,, ,,

1809.— ,, ,, ,, ,, ,,

Nov., 1811.—Only a few oysters.

Mar., 1813.—Very few young oysters.

1814.—Fished along with the Cheval Paar.

1816.— ,, ,, ,, ,, ,,

,, 1820.—Oysters 7 years old. Fished along with the Cheval Paar.

,, 1826.—"Great quantity of large oysters."

,, 1827.—"Plenty old oysters in 5 fathoms."

,, 1828.—South-east Modragam fished (yielded 305,234 rupees).

,, 1836.—Fished (6,000,000 oysters yielded 58,624 rupees).

,, 1856.—Oysters in great abundance on west of Modragam, 1 to 8 years old.

Nov., 1856.—Great abundance of oysters, mostly 4 years old.

Mar., 1857.—Oysters in abundance in large clusters, 3 to 5 years old.

Nov., 1858.—Sample of 12,000 lifted.

Mar., 1859.—North paar fished; oysters probably 4 to $4\frac{1}{2}$ years old (over 6,000,000 yielded 287,678 rupees).

,, 1860.—Remainder on north, 5 years old (800,000 oysters yielded 87,269 rupees), and younger ones, 4 years old, on south fished (nearly 3,000,000 oysters yielded 279,547 rupees).

Nov., 1860.—Oysters 8 to 12 months old.

,, 1861.—No oysters on the south-east portion. On the south and on the northern edge, abundance of healthy oysters, 2 to 3 years old. On the North Modragam, healthy oysters $5\frac{1}{2}$ years old.

Mar., 1862.—Oysters 3 to 4 years old, very healthy and abundant, covering 1 square mile; thickest on south part. Should be fishable in 1863.

Nov., 1862.—Millions of oysters 2 to $2\frac{1}{2}$ years old.

1863.—Oysters have totally disappeared. [Probably eaten by Rays.]

Mar., 1864.—No young oysters.

,, 1867.—No oysters.

,, 1868.—To the west and south-west of the bank there is much weed covered with young oysters.

Nov., 1868.—No oysters.

,, 1869.— ,,

Mar., 1870.— ,,

,, 1871.— ,,

,, 1872.—On South-east Modragam a small patch, 9 to 12 months old.

,, 1873.—Oysters have disappeared.

,, 1875.—Two beds of oysters, 2 years old, healthy and numerous on the north and south paars.

,, 1876.—The south bed almost disappeared and the north bed thinned. No dead shells.

Nov., 1876.—200,000 oysters fishable in March, 1877.

Mar., 1877.—North Modragam fished (yielded 4420 rupees).

Nov., 1879.—No oysters.

Mar., 1883.— ,,

,, 1885.—Oysters plentiful, 18 months old; Rays feeding on them.

,, 1886.—Two separate beds, 25,000,000 on north, 14,000,000 on south, oysters $2\frac{1}{2}$ years old; on the south bed mixed with some a year younger. Apparently no loss from Rays yet.

,, 1887.—Serious loss of oysters; north fished at once (yielded 103,664 rupees); south contained too many young oysters mixed with the old.

Nov., 1887.—Some oysters remaining.

Feb., 1888.—3,000,000 on north; 2,000,000 on south, mixed with some 1 year younger. Both banks fished, along with Cheval Paar.

Nov., 1888.—Very few old; no young.

,, 1889.—None.

Mar., 1893.—No oysters.

,, 1899.— ,,

,, 1900.—Small patch of young oysters.

,, 1901.—Two insignificant patches.

Mar., 1902.—North covered with young oysters; south has one bed of young and some of 3 years old.

April, 1903.—Some oysters present in clusters on the sand, and singly adhering to rock.

Mar., 1904.—Large quantities of $2\frac{1}{2}$-year-old oysters on both banks.

It is obvious, in looking over such a record as the above, that it is an incomplete history, and that, in the absence of certain data, we are unable to re-construct a perfect picture of the sequence of events. Still certain beds of oysters can be traced in successive years as follows:—

No doubt the 5 and 6-year old oysters recorded in 1804 and 1805 were those fished in 1806; and the spots of 3 to 4 years old found in 1805 were those fished in 1808 and 1809. But it remains doubtful when the oysters fished in 1814 made their appearance. Those fished in 1816 are very probably the young oysters noted in 1813; and it may be remarked that what may seem comparatively few when young, and small, and closely packed, will, if they live and spread out, be sufficiently numerous when large to form a respectable fishery. It may have been some of these same oysters that formed the 7-year old fishery of 1820. We have no data in regard to the oysters fished in 1828 and in 1836, and after that comes a gap of 20 years during which there are no records. During 1856 and 1857 oysters of all ages were apparently found in abundance, although, in the absence of any history, it may be permissible to doubt whether any were really 8 years old. It is also curious that the older oysters found during these two years and the following one were not fished. In November, 1858, a sample of 12,000 was lifted, and the oysters on the north bank, then estimated at 4 to $4\frac{1}{2}$ years old, were fished to the number of over 6,000,000. The following year what were left on the north bank, amounting to under 800,000 oysters, were fished along with nearly 3,000,000 younger ones from the South-east Modragam. The latter are referred to as 3 years old, but, judging from the high price obtained, it seems unlikely that they were so young.

Young oysters were found on the bank the following November, and again in November, 1861; and in March, 1862, the prospects for a fishery the following year were good. In November younger oysters were also seen "in millions," but in 1863 the oysters had "totally disappeared." This catastrophe occurred during the north-east monsoon, so it was probably not due to any exceptional disturbance of the ground, and from the remarks made by Twynam and Donnan in their Fishery Inspection Report of November, 1863, to the effect that the appearance of the shells brought up showed that they had been destroyed by some animals preying on them, it is very probable that the loss of this bed of oysters was due to an incursion of Rays. Sir W. Twynam thinks, however, that they were also injured by the heavy floods of 1862–63.

From this time there is a blank till 1875, when beds of 2-year-old oysters were

found, which yielded the small fishery on the North Modragam in 1877. In 1868, and again in 1872, quite young oysters were seen in the neighbourhood of the Modragams, but these came to nothing. Deposits of spat on weeds must always, in the nature of things, be of very uncertain value. A little extra wind or current in a particular week may drift the weeds with their precious burden on to unsuitable ground or out of the pearl-bank district.

Even if the weeds remain till they rot or the young oysters leave them, the exact nature of the bottom, and the presence of culch or suitable hard objects, may determine whether the spat will be overwhelmed in shifting sand or will start a fresh bed of oysters. No special causes, then, are required to account for the disappearance of weed and spat in its younger stages.

After the fishery of 1877 comes an interval of 10 years, the next fishery being in 1887. That must not be taken as implying that during that time the ground was in any way changed in its nature or unsuitable for oyster growth. Two things are necessary for a successful bed of oysters: first, the suitable ground, and, secondly, a supply of spat; and if an area has been fished out, as the North Modragam was in 1877, and no other adult oysters are present in the neighbourhood, it is easy to understand that no spat will be forthcoming, and that suitable ground may, if left to unaided nature, lie unoccupied for a series of years until, through some accident of winds and tides, or the slow migration of parent oysters, a deposit of spat is again brought into the region. This must have happened in the Modragams in the summer or autumn of 1883, as in March, 1885, oysters 18 months old were found plentiful, but being devastated by Rays. They were still fairly abundant the following year, but in 1887 the loss of oysters was becoming so serious that the north bank was fished at once and yielded nearly 9,000,000, which brought in over 100,000 rupees. In the following year, 1888, the few millions that remained on both banks were fished. On this as on several other occasions difficulties, delay, and loss of oysters were caused by the mixture of fishable old with much younger ones. This is, perhaps, inseparable from the method of fishing by means of native divers, but it is probable that if the oysters were dredged up in bulk, old and young together, from a steamer, most of the young could be separated rapidly by hand on board and thrown back before leaving the "paar" without excessive work, undue delay, or much sacrifice of the young oysters. The prospects of a fishery next year are good.

III. PERIYA PAAR KERRAI.

The relation of this small northern paar to the great Cheval district is seen in fig. 3, on p. 14, and its leading physical and biological characters will be found noted in Part I. at p. 108. The fishery record is as follows:—

Mar., 1802.—Oysters 4 to 5 years old.

Oct., 1802.— ,, $4\frac{1}{2}$ to $5\frac{1}{2}$ years old, many dead shells.

Mar., 1804.—Fishery.

Mar., 1805.—Dead shells.
Oct., 1809.—Young oysters, 2 years old.
Nov., 1810.—Abundant oysters, $1\frac{1}{2}$ to 3 years.
,, 1811.—Oysters present.
Mar., 1813.— ,, 2 to 3 years old.
Nov., 1815.— ,, 6 and $6\frac{1}{2}$ years old—to be fished.
,, 1816.— ,, all dead—no fishery.
,, 1820.— ,, 4 years old.
,, 1821.— ,, dead.
Oct., 1828.—Small patch of good oysters.
Mar., 1832.—Oysters present.
,, 1833.—Fishery (yielded 320,896 rupees).
,, 1835.— ,, (16,000,000 oysters yielded 403,460 rupees).
,, 1836.— ,, (3,000,000 ,, 40,158 ,,
,, 1870.—Two patches of young oysters.
,, 1871.—No oysters.
,, 1876.— ,,
,, 1886.—Two small patches, 3 to 6 months old.
Nov., 1887.—Small patch of oysters about 2 years old.
Mar., 1893.—No oysters.
,, 1899.— ,,
,, 1901.—On south-west 7,000,000 oysters 1 to 2 years old.
,, 1902.—Many oysters about 3 years old.
,, 1903.—Fishery (1,500,000 oysters yielded 32,861 rupees).
,, 1904.—Oysters left last year now gone.

This bank, as might be expected from a northerly extension of the North-east Cheval, although of small size is quite a profitable and reliable paar. It has yielded 5 fisheries that are recorded and one at least, that of 1815–1816, has evidently been lost through the oysters being left too long unfished.

Those of 1820, again, should probably have been fished that year. During the 100 years of our record we have evidence of at least 8 deposits of spat on this bank, but there may well have been more, as this little paar did not until recently receive such close attention as its gigantic neighbour, the Cheval. The patch of hard bottom forming the paar appears to vary considerably in extent and shape from time to time, as the diagram (fig. 15) shows. The variations are, no doubt, due to movements of the sand, and any losses of oysters that have occurred are probably due to that cause or to the incursions of large Rays (Trygonidæ). In March, 1902, we found 3-year-old oysters in quantities which Captain Donnan estimated at over 21,000,000.

In November, 1902, the fishable oysters were estimated at 8,000,000, and in February, 1903, Captain Legge put the figure at a little under 7,000,000.

At the actual fishery, a month later, only 1,473,297 oysters were lifted, but this small number was due in part, at least, to the fact that the great depth (9 fathoms as compared with 6 fathoms on the Cheval) caused the collapse of several divers and discouraged the others, so that it was found impracticable to work longer on the bank. The marked decrease in the number of oysters during 1902 was undoubtedly due to large Rays. Mr. HORNELL found samples of crushed oysters and many broken shells and characteristically comminuted fragments, which he has sent to me, and which I agree are the result of the action of the tooth plates of large Elasmobranchs such as *Trygon uarnak* and its allies.

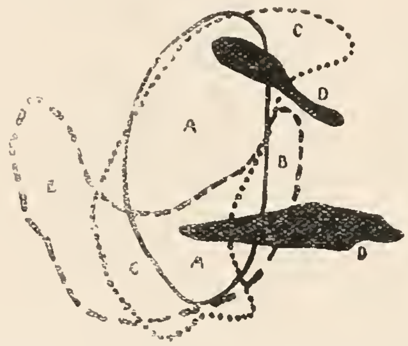


Fig. 15. Plan of the Periya Paar Kerrai. The whole line surrounding A shows the area as inspected in 1882, the dashed line round B shows the paar in 1884, the dotted line round C shows the condition in 1886, while the two black patches indicate the parts fished in 1835 and 1836.

IV. KONDATCHI PAAR.

This is a part of the Cheval group, and evidently forms an extension of the southern end of the East Cheval. Although only one fishery is recorded from this paar, that of 1801, oysters have several times been fished or traced extending to the eastward from the southern part of the Cheval paar in the direction of the Kondatchi. Consequently it is quite possible that a bed might mature and a fishery might take place on this just as on any other part of the Cheval region.

No detailed record of the history is necessary, but it may be added that when we examined this bank in March, 1902, it had about 5,750,000 oysters. These were much reduced in November, 1902, and had nearly all gone by March, 1903, and it seems probable that the destruction in this case may be due to the great numbers of large Star-fishes, and especially of *Pentaceros*, present on the bank.

V. PERIYA PAAR.

This lies outside the other paars in the Cheval district, about 18 miles from land and close to the top of the bank that runs steeply down into deep water. An account of the leading physical and biological features was given in Part I., at pp. 76 and 110. The remarkable fishery record is as follows:—

Mar., 1813.—Oysters 2 years old, in clusters, sticking to small detached rocks.
Nov., 1863.—Young oysters, 6 months old, on piece of ground 3 × 2 miles.
Mar., 1864.—Oysters about 12 months old appearing to be same as last year, but 2 miles further west.

Mar., 1878.—On the Kottapakku paar, where oysters were found in 1802 (extension of Periya to south-east), found 3,500,000 oysters, but there were 13 per cent. dead shells. They were of the "Kottapakku" variety.

Nov., 1878.—Oysters dying on Kottapakku Paar. Pearls valued at Rs. 17.29 per 1000. Small fishery suggested for March.

Mar., 1879.—Bank fished (yielded 95,694 rupees).

Feb., 1880.—Abundance of young oysters.

Mar., 1882.—No oysters on the bank.

April, 1883.—Neighbourhood of ground fished in 1879 thickly covered with young oysters 6 to 9 months old.

Mar., 1884.—Oysters still on bank, mixed with others 3 months old.

,, 1885.—Older oysters gone and very few of the younger remaining.

,, 1886.—No oysters on the bank.

Nov., 1887.—Abundance of young oysters 2 to 3 months old.

,, 1888.—Oysters of last year gone and new lot come, 3 to 6 months old.

,, 1889.—Oysters of last year gone; a few patches present, 3 months old.

Mar., 1892.—No oysters on bank.

,, 1893.—Abundance of oysters 6 months old.

,, 1894.—No oysters on bank.

,, 1895.— ,, ,, ,,

,, 1896.—Abundance of young oysters 3 to 6 months old.

,, 1897.—No oysters present.

,, 1898.— ,, ,, ,,

,, 1899.—Abundance of oysters 3 to 6 months old.

,, 1900.—Abundance of oysters 3 to 6 months old; none of last year's remaining.

,, 1901.—Oysters present, 12 to 18 months old, but not so numerous as in preceding year.

,, 1902.—Young oysters very abundant, 2 to 3 months old. Only a few patches of older oysters (2 to 2½ years) remaining.

Nov., 1902.—All the oysters gone.

April, 1903.—Some oyster spat seen on Sargassum weed.

Mar., 1904.—Bank of 5 × 2 miles covered with young oysters (3 months old) from end to end.

This is an extraordinary history. In 100 years there has only been one small fishery, that of 1879, and yet the Periya Paar probably receives more deposits of spat than any of the other banks. Since 1880 the bank has been naturally re-stocked with young oysters at least 12 times without yielding a fishery. The destruction and the reproduction are both, in this case, on an enormous scale. As this bank was dealt with fully in the Narrative (p. 76) in Part I., I need only say here (1) that the

destruction of the successive broods of young oysters seems to be due to the configuration of the ground and its exposure to the south-west monsoon, and (2) that the constant production of fresh spat renders possible the transplantation of young pearl-oysters in enormous quantities from the Periya Paar to other safer grounds further inshore, such as parts of the Cheval district.

VI. DUTCH MODRAGAM PAAR.

This paar, notwithstanding its name, lies at a considerable distance from the better known North and South Modragams. It is about 10 miles to the south-west, and on the other hand is only about a mile to the north of Karativo Paar. It clearly belongs to the Karativo and Muttuvaratu group rather than to the Cheval and Modragam series of paars. It has been described in Part I., at p. 111.

This is a disappointing but at the same time a promising bank. It has apparently not yielded a fishery in British times, and yet it has, on various occasions, been found covered with oysters both young and old (over 3 years). It has a rough hard bottom, suitable for affording good attachment, and it evidently receives deposits of spat, *e.g.*, one in the summer of 1899 and one in the summer of 1902. Consequently, notwithstanding its poor record in the past, I see no reason why it should not at any time yield fisheries like those of the neighbouring Karativo and Muttuvaratu Paars.

It is only of the last few years that we have detailed records; but these, as given below, will serve as a sample to indicate the nature and prospects of the bank.

Recent History of the Dutch Modragam Paar.

April, 1899.—No oysters.

Mar., 1900.—386 acres covered with young oysters 3 to 12 months old (*fide* Donnan).

,, 1901.—Two small detached beds of oysters from $1\frac{1}{2}$ to 2 years old, 1,750,000, rapidly disappearing since last year; about 51 acres of ground covered by these oysters (*fide* Donnan).

April, 1902.—A small bed of 387,500 square yards (= 80 acres) bearing oysters of 2 to $2\frac{1}{2}$ years old (*fide* Donnan).

Nov., 1902.—Oysters were present which, though apparently not over 2 years old, must have been $2\frac{1}{2}$ to 3 years of age. They were mixed with quantities of young, from 6 to 8 months old.

Feb., 1903.—At the place where Mr. Hornell made an examination in a diving dress, very many pearl oysters lay thickly spread on the bottom, very similar in appearance and size to those of Muttuvaratu; age apparently $3\frac{1}{2}$ years, with considerable numbers of younger and smaller ones.

Mar., 1904.—Oysters plentiful; apparently the majority are not more than 2 to $2\frac{1}{2}$ years old. These represent the young spat which was noted as abundant in November, 1902; their growth has been at the expense of the older ones that were present in 1902, and which have been smothered or killed out by the competition of the more vigorous and numerous young.

VII. KARATIVO PAAR.

A short account of the characters of this paar will be found at p. 113 in Part I. Its fishery record is as follows:—

Nov., 1829.—Oysters 5 years old.
Mar., 1832.—Fishery (yielded 45,810 rupees).
1863.—Found nothing.
Mar., 1864.—A few oysters 12 months old; do not look healthy.
,, 1867.—Only a few scattered oysters.
,, 1868.—To the south-west, weed covered with young oysters.
,, 1870.—Patches of weed covered with young oysters.
,, 1871.—No oysters.
,, 1875.— ,,
,, 1882.— ,,
,, 1883.— ,,
,, 1886.—4,000,000 oysters, 18 months old, on the fishing ground of 1832; 1,500,000, 3 years old, thinly spread, and 8 per cent. dead.
May, 1887.—Oysters apparently all gone from fishing ground of 1832; young oysters present, not enough for fishing.
Nov., 1889.—3,000,000 of the oysters found in 1886; small fishery held at once.
Mar., 1890.—Some fished with fishery at Muttuvaratu.
Nov., 1890.—Most of the oysters had died out.
Mar., 1891.—Remaining oysters (200,243) fished with fishery at Muttuvaratu.
,, 1893.—No oysters.
,, 1899.— ,,
Mar., 1900.—Bare of oysters.
,, 1901.—"A fairly large bed of oysters (234 acres) of from 6 to 12 months old"—number estimated* 30,000,000.
April, 1902.—25,330,000 oysters, from $1\frac{1}{2}$ to 2 years old, occupied a bank having an estimated area of 1,570,850 square yards (= 324 acres).
Nov., 1902.—Not inspected.
Mar., 1903.—Mr. HORNELL's inspection by means of diving apparatus showed that the oysters present in April, 1902, had practically all disappeared.
,, 1904.—Old oysters all gone. Some younger (2 years old) have appeared.

* But little importance can be attached to numerical estimates of oysters at this age, and Mr. HORNELL advises that such estimates should not be made use of except in the case of banks of mature oysters.

If we include "the paar near the Isle of Cardieu, off Karativo Island," as recorded in 1832, we have four fisheries in all—the other three being of more recent date (1889–91). A great gap, however, exists in the records—from 1832 to 1863—so it is possible that this, like the neighbouring Muttuvaratu Paar, was lost sight of or neglected for some time.

It is evident that spat has appeared on the bank from time to time—three times between 1864 and 1870—and in all probability the area is as good for rearing as the Muttuvaratu Paar, and as likely to yield fisheries. I attach no importance to spat "on weed" disappearing. At that stage it is too uncertain and too much at the mercy of the winds and waves to be regarded as more than a *possible* source of supply. Besides if the weed be carried away from one paar it may drift on to another, and so is not necessarily lost, although it may be lost sight of.

The oysters fished in November, 1889, must have been those that were 18 months old in 1886, and if so, the observation of May, 1887, that the oysters were gone from the fishing ground of 1832 must have been erroneous, unless it be that the oysters shifted their ground, were temporarily lost, and were found again in 1889.

A large deposit of young oysters must have appeared in the summer and autumn of 1900. It was surveyed in March, 1901, and again in April, 1902, when it occupied a still larger area. This increase in area may have been due to spreading of the oysters, or more likely to differences in the areas examined at the two inspections. It is seldom that successive inspection areas closely agree in position—it being practically impossible to place the inspection vessel on the same bearings at successive inspections.

In the following spring, however, Mr. Hornell's inspection showed that these oysters had nearly all gone, and in March, 1904, the bank was practically bare again. If there is no mistake in the locality, and the oysters have not been shifted to some adjoining ground, this is a disappointing case of a bed which ought to have yielded a good fishery, failing after it seemed to be well established. This paar, it must be remembered, is just on the edge of the deep water, exposed to currents, and therefore in a somewhat precarious condition. The loss of these oysters was very probably due to monsoon currents in the summer and autumn of 1902.

VIII. MUTTUVARATU PAAR.

An account of the leading physical and biological characters of this important bank was given in Part I., at p. 114. The fishery record is as follows:—

Dec., 1820.—Oysters, 1 year old, on rock—very thick.
Mar., 1826.—Quantities of large oysters.
,, 1827.—Plenty of old oysters.

* * * * * * *

,, 1886.—27,000,000 oysters 18 months old.

Nov., 1887.—49,000,000 3-year-old oysters firm on rocky ground.

Dec., 1888.—Oysters have not suffered. Sample lifted 4 years old—fishery recommended.

Mar., 1889.—39,000,000 oysters fished. Oysters were young (yielded 498,377 rupees)—small thick "Kottapakku" variety.

Nov., 1889.—Still a large number (30,000,000).

Mar., 1890.—Over 33,000,000 oysters fished (yielded over 300,000 rupees)—much mixed in size; plenty of small pearls.

Nov., 1890.—Oysters still there in quantity.

Mar., 1891.—Over 44,000,000 oysters fished (yielded over 900,000 rupees)—much mixed, but for the most part full-grown, rich in pearl; rapidly dying off—many putrid and of offensive smell when brought to the Kottus.

„ 1893.—No oysters.

„ 1895.— „

„ 1896.—127 dives showed oysters 3 to 6 months old. 499 dives were unproductive—bare rock.

„ 1897.—260 dives gave bare rock; 410 showed the presence of young oysters, about 1 year old, estimated at 72,000,000.

„ 1898.—Oysters, 2 to $2\frac{1}{2}$ years old, reported from 278 dives; 429 reported bare rock.

„ 1899.—The bank is again practically clear of oysters. All but total disappearance. Probably due to ravages of large Rays.

„ 1900.—Abundance of young 3 to 9 months old.

„ 1901.—Abundance of young 18 months old; 178,000,000. Large area on north-west side of southern portion has been completely cleared since last year.

„ 1902.—Oysters still present in enormous abundance; 277,000,000.

Nov., 1902.—Considerable reduction in number, and appearance stunted; many yellow individuals present.

Mar., 1903.—Still very numerous, about 125 to the square yard in places.

„ 1904.—Some old still remain, but dying off rapidly. Considerable numbers of younger ones, about 1 year old, now present.

The history of the Muttuvaratu Paar is interesting because of the great gap from 1827 to 1886, during the greater part of which period the bank had apparently been lost sight of. In 1820, 1826, and 1827 there are entries of quantities of old oysters on the rocky bottom,* but there are no records of a fishery until after Captain DONNAN

* Captain DONNAN, however, writes to me that he thinks it probable that these early inspections were on HAMILTON'S Muttuvaratu Paar, which lies between 2 and 3 miles to the north-east of the true Muttuvaratu; in which case we have no record of the true paar from the time of the Portuguese until DONNAN re-discovered it in 1860 or 1861.

re-discovered* the bank about 1860, and watched it carefully after his appointment as Inspector in 1863. And yet there is reason to believe that it was known to the natives, and that there may have been native fisheries there in early times, extending even to the period of the Portuguese occupation. JOHANN JACOB SAAR (1662), in describing the capture of Manaar by the Dutch, referred to one important pearl bank at 3 miles' and another at 10 miles' distance from Manaar. These miles, being Dutch, are from $3\frac{1}{2}$ to 4 times as long as English, and consequently these two banks were respectively from 10 to 12 and from 36 to 40 miles to the south—distances which correspond with the positions of the Cheval and Muttuvaratu paars. The Muttuvaratu Paar is 3 miles in length and covers the ground between 36 and 39 miles from Manaar. It is unlikely that so much importance should have been attached to this bank by the Portuguese and the Dutch unless it had yielded fisheries.

When Captain DONNAN inspected the bank in 1886, it had what was estimated at 27,000,000 of oysters in their second year. There must have been many more. When inspected in November, 1887, a still larger estimate was made (still much under the mark), and this excellent bed of oysters yielded eventually the three very profitable fisheries of 1889, 1890, and 1891, during which in all about 117,000,000 of

* The story of this discovery is so interesting that I add it here in Captain DONNAN'S own words. He told it to me on the pearl banks in 1902, and I have now got him to write it out, and I quote from his letter of July 11th, 1904:—"My first visit to the Muttuvaratu Paar was, as far as I can remember, in November, 1860, or in March, 1861. I was then in command of the s.s. 'Pearl,' and was on a visit to the pearl banks under the direction of Captain PRITCHARD, Master Attendant at Colombo and then Acting Superintendent of the Pearl Fishery. PRITCHARD gave the chart of the banks to me and told me to anchor on each bank according to the bearings, but on getting on the chart bearings of the banks off Karativo I found we were off the bank of soundings, and that the chart was unreliable. I therefore suggested to PRITCHARD that I should go down south of Dutch Bay again and start afresh, steering north and keeping in 8 fathoms water, and stopping every quarter of a mile or so and sending down a diver. PRITCHARD thought that was a good idea and told me to carry it out, which I did. After a great many stops and dives of 'Chippie Illai' (no oysters) at last the diver reported oysters, so I anchored and sent out the boats to inspect, the result being a find of a bed of full-grown oysters mostly all dead and very few found alive. This bank would no doubt have yielded a good fishery if it had been discovered a year sooner. I made a note of the position of the bank, and when I became Inspector of Pearl Banks I determined to visit that spot every two or three years, as I imagined that the spot where oysters had matured would be a likely spot for them to come on again, but it was not until 1886 that I was rewarded for my perseverance by finding a large bank of young oysters which yielded three fisheries in succession.

"When the oysters were approaching maturity, I looked up STEUART'S book to see if he had any record of a bank in that neighbourhood, and I found that in the Dutch time a native of Calpantine had given information of a bank, named Muttwartu Paar, some 8 miles north-west of Calpantine Flagstaff. There was no information as to the position of the flagstaff, but I imagined that the bank referred to might possibly be the one I had discovered. I thereupon consulted the Adigar of Manaar as to the meaning of the word Muttwartu, and he replied that the proper name must be Muttuvaratu Paar, which means the bank where the pearls come, so I then decided that the bank I had discovered should bear that name.

"It is, I think, very probable that my Muttuvaratu Paar is the same as the one referred to in the Dutch records, and in that case my discovery was only a re-discovery of an old bank that had been lost for ages."

oysters were lifted. These fisheries show well how pearl oysters increase in value as they get old, the last one (1891) when the oysters were rich in pearl being much the most remunerative, and in fact being the only fishery since 1814 that has brought in nearly 1,000,000 of rupees. But the record also shows the risk there is in trying for the enhanced value by delaying the fishery once the oysters are over 5 years of age. In 1891 this bed must have been 6 years old, and they are described as rapidly dying off, many being already dead and putrid.

The next deposit of young oysters on the Muttuvaratu, found in March, 1896 disappeared* in 1898–99 (a winter of exceptionally heavy rains and storms); and a fresh population made its appearance a year later and has been recorded at all the inspections since. In March, 1902, it was estimated by Captain Donnan at the enormous figure of 277,000,000. This number has probably been greatly reduced since by disease and the ravages of enemies, and it is doubtful whether sufficient will survive to yield a fishery next year when these oysters will be over 5 years of age.

The adult oysters of the Muttuvaratu Paar are of small size and have a peculiarly stunted appearance. They are infested with parasites, and also seem liable to a diseased condition in which the mantle and other tissues become of a yellow colour. In April, 1903, over 11 per cent. of the oysters examined were affected with this disease. The Muttuvaratu, like the Karativo and the Dutch Modragam, seems excellently adapted for the deposit of spat, but less reliable than the Cheval as a rearing ground.

IX. CHILAW PAARS.

There are several paars, large and small, in the neighbourhood of Chilaw, which have been described in Part I. (pp. 117, 118). The following record covers several of these :—

Mar., 1802.—Oysters 5 years old. On Jokkenpiddi, $4\frac{1}{2}$ and 4 years old.

,, 1803.—Jokkenpiddi fished (yielded 163,154 rupees).

Oct., 1804.—Nothing on Jokkenpiddi.

Nov., 1812.—On the Jokkenpiddi Paar, oysters 4 and 5 years old, with young ones attached, estimated to be fished in 1815. On Karkopanni Paar, abundant oysters 2 to 3 years old, and to the north, some of 4 to 5 years. On the Chilaw Paar a small bank of oysters 4, 5, and 6 years old, half of them dead.

Nov., 1814.—On Karkopanni the oysters are thin and scattered, upwards of 6 years old, and there are many dead shells—to be fished in March. On Jokkenpiddi, only dead shells. On the Chilaw Paar nothing but rock and dead shells.

* Captain Donnan informs me that it was his report on this disappearance which caused Sir E. Walker, then Acting Governor, to write to the Secretary of State asking for an expert enquiry into the condition of the pearl banks, and so gave rise to the present investigation.

Mar., 1815.—Small fishery on Karkopanni (yielded 5842 rupees).

Dec., 1820.—On the Jokkenpiddi, a few oysters 2 years old. On the Karugugalie Paar a large bed of oysters 1 to 1½ years old.

April, 1871.—No oysters.

,, 1875.—On Jokkenpiddi, a small patch. On Chilaw Paar, a large bed 6 months old.

,, 1876.—Still some oysters; doubtful if they are enough for fishery.

Nov., 1876.—On Chilaw Paar, 500,000 oysters 2 years old. On Jokkenpiddi, 250,000, 3 years old.

April, 1878.—On the south part of the Jokkenpiddi Paar there is a bed of oysters of "Kottapakku" variety, 4 years old. The others seen on Jokkenpiddi in 1876 are nearly all gone. Those on the Chilaw Paar are nearly all gone.

Nov., 1878.—Oysters on Jokkenpiddi all gone.

April, 1882.—On Chilaw and Karkopanni, beds of 2-year-old oysters.

,, 1883.—Last year's oysters still exist and thrive.

,, 1884.—Oysters dying off fast. Small fishery held on Chilaw Paar (yielded 17,153 rupees).

Nov., 1884.—Small fishery off Chilaw, and on Karkopanni.

April, 1885.—Three beds of young oysters 6 months old.

Dec., 1888.—Only one patch found in 1885 remains; oysters very few and scattered.

Nov., 1889.—Not inspected.

April, 1899.—No oysters.

Mar., 1901.— ,,

April, 1902.—Chilaw Paar had a bed of young oysters, 6 to 9 months old, covering about 1,120,000 square yards. Jokkenpiddi had many young oysters 3 months old.

Mar., 1903.—Not inspected.

Mar., 1904.—Oysters over 2 years old still present.

From the early Sinhalese records it seems probable that the banks off Chilaw were much more productive in ancient times than they have been during the last century. Chilaw seems, in fact, to have been formerly as important a fishery centre as Chilavaturai. The Sinhalese poem, 'Kovul Sandésaya,' written about the middle of the fifteenth century, refers to the pearl-lined shore of Chilaw in such a manner as to suggest that this locality was the centre of the Southern, or Sinhalese, pearl fisheries. In Portuguese and Dutch times its fame seems to have been eclipsed by that of the more northerly banks worked from the settlement at Manaar; but as the Chilaw region is still productive, and yielded at least three fisheries in the nineteenth century, it is possible that beds of oysters may have remained undiscovered and unfished. The record shows great gaps—from 1820 to 1871 and again from 1888 to

1899—so that probably the history looks less favourable than the reality may have been.

The fishery in 1803 was on the Jokkenpiddi Paar, and that in 1815 was on the Karkopanni, so that the fishery of 1884 was the only one on the Chilaw Paar proper—all were small fisheries. On the whole the record is uneventful, there have been no great successes and no marked catastrophes. There are no new conclusions to draw, but the banks may still be of value. There seems no reason why a bed of oysters should not mature on occasions, and parts of the Chilaw region will at least serve from time to time to supply a stock of young oysters to the Cheval or other paars that require replenishing.

Pearl fishing fleet at work on the Cheval Paar.

CONCLUSIONS.

This examination of the records of the principal pearl banks has served to emphasise some of the conclusions that were put forward in Part I. of this Report. In tracing the history of the different beds of oysters, in considering how the paars differ from one another and in trying to find the causes of such catastrophes as have occurred, we are brought to see :—

(1.) That man can do comparatively little to mitigate the severity of such influences as tell against the life and prosperity of the pearl oyster. He may possibly, if it be thought wise, to some extent diminish the ravages of certain carnivorous fishes, and he may by dredging the banks improve their condition and remove competing organisms, and also thin out beds that are overcrowded, but he is powerless against the invasion of microscopic parasites and of sand over-washes caused by monsoons, storms and tidal currents;

(2.) That much can be done, however, to preserve and make the best of what oysters we have, by careful inspections, by judicious transplantations and by speedy fisheries undertaken at the right moment.

Inspections should be as accurate, as frequent and as extensive as possible. They should extend beyond the conventional limits of the known paars and aim at exploiting new areas. It must be remembered that the greater part of the shallow shelf that forms the Ceylon side of the Gulf of Manaar out to the 10-fathom or 12-fathom line is potential "paar ground" and that new deposits of spat might be found any day on almost any part of it. It is impossible, of course, to inspect the whole area in detail every year, but it is important that lines of observations should be run across at least the more likely parts, and that could readily be done by means of a series of dredgings from a small steamer. The inspections should give early intelligence as to (*a*) new deposits of young oysters which might possibly require to be transplanted to safer ground, and (*b*) the necessity for a speedy fishery in order to save some threatened bed of adult oysters from being totally lost.

The necessity for transplantation has already been pointed out in Part I. It will suffice now to state that transplanting is the only means by which (*a*) many beds of young oysters can be saved from almost certain destruction, and (*b*) large areas of suitable ground can be supplied with a sufficient oyster population.

The relative efficiency of different methods of transplanting and also of speedy fishing by means of dredges or trawls—to be used in emergencies, when a bed of oysters might be lost if left unfished—are matters upon which Mr. Hornell, as Inspector of the Pearl Banks, is now experimenting, and it is hoped that in our

recommendations which will conclude the final Part of this Report we may be able to incorporate results obtained from his present experiences.

Finally, there are prospects of good fisheries both next year and in 1906 on the Modragams and several divisions of the Cheval Paar—possibly also on the Muttuvaratu and the Dutch Modragam in the latter year. The results in 1907 and the immediately succeeding years will, so far as we can now see, depend upon whether large measures of transplantation are adopted without delay.

ANATOMY OF THE PEARL OYSTER.

(*Margaritifera vulgaris*, SCHUM.).

[WITH NINE PLATES.]

THE Anatomy of the Ceylon Pearl Oyster has never been adequately investigated. L. G. SEURAT, in his little book 'L'Huître Perlière,'* gives a short account of the structure of one of the large pearl oysters of the Pacific, *Meleagrina margaritifera*, and makes a few remarks upon the shell and some of the organs of the much smaller Ceylon pearl oyster (then known as *M. fucata*). Several writers on Molluscan morphology have described special points in our animal—or closely related species. For example, GROBBEN† gives some information as to the heart, PELSENEER‡ as to the branchiæ and nervous system, RIDEWOOD§ discusses the gill structure in *Avicula argentea* and various species of *Meleagrina*, and THURSTON‖ gives a few figures and a brief description.

The works of GARNER, RAWITZ, THIELE and BIEDERMANN all contain useful information bearing more or less on our subject. H. L. JAMESON¶ has recently written on the identity and distribution of the mother-of-pearl oysters and has determined that the Ceylon form commonly known as *Avicula fucata* is in all probability the *Perlamater vulgaris* of SCHUMACHER, belonging to the modern genus *Margaritifera*, and must therefore be known as *Margaritifera vulgaris*, SCHUM.

In the following account of the anatomy of the Ceylon pearl oyster, while the aim has been to give a fairly complete description of all parts of the body, those organs have been treated most fully which are of greatest importance in connection with the operations of the pearl fisheries and of the oyster culture. And, as in biological work generally Structure should never, if possible, be dissociated from Function, what information could be given in regard to the uses of the parts has been supplied when discussing the anatomy.

I have included as much as possible from our field-notes in regard to the habits and actions of the living animal as seen in our experimental tanks, since it is a rare event

* 'Encyclopédie Scientifique des Aide-mémoire.' Masson et Cie, Paris, 1901.

† 'Arbeit. Zool. Instit. Wien,' Band VII., p. 410.

‡ 'Archives de Biologie,' tome XI., p. 198, 1891.

§ 'Phil. Trans.,' B, vol. 195, 1903, p. 147.

‖ 'Madras Government Museum Bulletin,' No. I., 1894, p. 18.

¶ 'Proc. Zool. Soc.,' April 16, 1901, p. 372.

for the naturalist to have such an animal as this alive under observation. It will be noticed that certain of our figures—drawn by Mr. HORNELL—are taken from the living animal. Some of the photographs are his, others are my own.

Our pearl oyster and a number of allied "mother-of-pearl" shell-fish belong to the family AVICULIDÆ, which RIDEWOOD has recently shown to be more nearly allied to the PECTINIDÆ (scallops) and SPONDYLIDÆ, in gill structure, than to the OSTREIDÆ (the true oysters). They are therefore placed in the order ELEUTHERORHABDA, characterised by the relative freedom of the gill filaments (see description below), while the OSTREIDÆ and PINNIDÆ are placed in the group EULAMELLIBRANCHIATA. The order Pseudolamellibranchiata, in which the pearl oysters and their allies were formerly placed, has thus been abolished.

The general characters of the AVICULIDÆ (pearl oysters and their allies) are as follows :—

The shell is usually inequivalve, the dorsal margin straight, often very long and forming anterior and posterior wings or "auricles," the lateral teeth of the hinge-line are much prolonged and may be inconspicuous, the minute structure of the shell is "cellular"; the mantle lobes are not fused, siphons are absent; the foot is moderately long, tongue-shaped, with a well-developed byssus gland; the posterior adductor muscle is very large and nearly central, the anterior adductor is usually absent. The gills may or may not fuse in part with the mantle, gill lamellæ plicate and heterorhabdid, with both descending and ascending filaments which are held in position to their neighbours by "ciliated discs" placed at intervals along the filaments.

These and other important points in structure will be more fully described and explained in the pages below and are shown in some of the figures on the plates.

SHELL.

The bivalve shell of the Ceylon pearl oyster, *Margaritifera vulgaris*, SCHUM. (= *Avicula fucata*, GOULD), is inequivalve, the left valve being deeper or more convex externally than the right. Each valve is more or less rounded in outline, with a flattened dorsal edge ending in projecting wings or "auricles" in front and behind (Plate I., figs. 2, 3, 4). The dorso-ventral and antero-posterior diameters are much the same, and in a 4-year old specimen measuring 9·5 centims. in length (dorso-ventrally) the breadth (antero-posterior) is 9 centims. Two shells, both 8·5 centims. long, measured respectively 7 centims. and 8 centims. in breadth. Plate I., fig. 5, shows an unusually narrow form. Other variations in the shape of the shell are shown on the plates—Plate I., fig. 4 is an unusually straight and fig. 6 an unusually oblique form. In handling some thousands and seeing some millions of these shells, as we have done, one cannot but be struck by the great variation in form and markings. Probably some of the supposed species of *Margaritifera* are merely varieties of the Ceylon form.

The shell is very thin, about 1·5 millims. over the greater part of its extent, and is lined by an exceedingly brilliant layer of nacre or mother-of-pearl. The outside of the shell is usually marked by 6 or 8 radial bands of dark red or reddish-brown on a pale yellowish ground. These colours are brightest and best seen in young specimens, as in the older shell they become dulled and obscured on the outside by incrustations and growths (Plate II., fig. 2). They are, however, usually visible even in large specimens on the inside of the valve on the ventral margin (see fig. 1). The outer surface in the young shell is also marked by concentric ridges or projecting imbricating lamellæ, which grow out at intervals to form spatulate or finger-like processes (Plate VII., fig. 14), which may be over 12 millims. in length. These are sometimes seen in the old shell (Plate I., fig. 2). The layer of nacre ends from 10 millims. to 15 millims. back from the free edge of the shell (Plate I., fig. 4), and at that point the shell in a well-grown specimen is about 1 millim. in thickness. From this the shell thickens gradually towards the dorsal edge, reaching an average of 2 millims. at about the point of greatest convexity of the valve.

In thick shells it may be as much as 3 millims. at this point, and an examination of the section shows that this increased thickness is due entirely to the nacre, which may be 2 millims., while the prismatic layer is only 1 millim. Over the greater part of the shell these two layers are of equal thickness, say from 0·5 millim. to 1 millim. each. On the anterior ear of the shell, forming the side of the byssal notch, there is a thickening of the shell up to about 5 millims.; and at the hinge, in the mid-dorsal line, another local increase may reach to 8 millims.

At the ventral edge the shell beyond the lining of nacre gradually decreases in thickness, and in a rapidly growing shell the free edge is flexible and horny in consistence, being composed of periostracum and a thin layer of prismatic shell still imperfectly calcified. Two shells from Kondatchi Paar (17th November, 1902), measuring 7 centims. in length, have this delicate margin, free from nacre, extending up to 2 centims. in width, not including the processes at the edge (Plate I., fig. 3).

On Plate I., figs. 1 and 2 show the contrast between an unusually smooth and an unusually inbricated shell; figs. 3 and 4 show variations in the development of the nacre and the margin, and figs. 5 and 6 marked differences in the shape of the shell. The "auricles" and the byssal notch also vary much in their development, as may be seen from the figures.

The hinge line is a narrow ridge running along the greater part of the straight dorsal edge and in contact with its fellow of the other valve, but not conspicuously cut up into projecting teeth. Much elongated, narrow, ridge-like lateral teeth are present. Outside the middle third of its length is the large black elastic ligament (see Plate I., fig. 4). It may measure in an adult shell about 20 millims. in length and 5 millims. in breadth. The ligament serves to open the shell, and so is antagonistic to the adductor muscle. Alongside the ligament and extending from the hinge line upwards to the umbo (the most prominent point of the valve, placed in front of

the ligament near the anterior end of the dorsal edge) is a sloping area of roughened shell, marked with close-placed lines of growth. This area (Plate I., fig. 4) becomes much more extensive, and less vertical in its slope, because of an increased thickening of the hinge, in old shells, and its condition is a good guide to the age after the shell has ceased to grow actively in length and breadth.

The shell is composed of three layers, outer, middle, and inner. The very thin outer layer is the uncalcified, cuticular "periostracum," an extremely delicate horny layer which allows the colour of the layer below to show through, and which becomes worn off in old shells. At the free margin of the shell the periostracum is very thin and transparent, extends beyond the calcareous matter, and is reflected to join the surface of the ectoderm cells of the mantle-edge in the longitudinal groove where it is secreted. The periostracum is seen in several parts of the section represented in Plate VIII., fig. 1, and also as a detached film in the groove on the mantle-edge in Plate VIII., fig. 2, *Per. ostr.*

The middle or "prismatic" layer of the shell shows what CARPENTER called, in *Pinna*, a "cellular" structure being formed of calcareous prisms or columns running transversely to the surface, and appearing as polygons in section (Plate VII., figs. 14 to 18, and Plate VIII., fig. 1).

The carbonate of lime is laid down in an organic matrix of conchiolin, and is found in the adult pearl oyster to be in the form of the mineral aragonite. The prismatic layer is deposited by the mantle epithelium near the free edge, just behind the margin which forms the periostracum; and many such layers of prisms may be formed successively, each new one inside the last, as the shell grows. At the free edge of the shell and on the imbricating ridges these films may separate and stand out as in the section shown on Plate VIII., fig. 1. The red and brown coloration of the shell is in this layer, certain of the prisms being charged with pigment, as shown in fig. 18 on Plate VII. Various stages in the decalcification of the prisms is shown in fig. 19. Complete decalcification reduces a section to a honey-comb-like network of conchiolin (as shown in Plate VII., fig. 17), which is continuous with the very similar organic periostracum lying over it.

The inner layer is the "nacre," formed of numerous delicate lamellæ of the organic matrix conchiolin, and calcareous matter. It is transparent under the microscope, allowing the "cellular" structure of the prismatic layer to show through it clearly (see Plate VII., fig. 15), and is almost structureless, having merely a fine granular appearance (Plate VII., fig. 21) in surface view under a high power. The layers of which it is formed show as a series of very closely placed contour lines (Plate VII., fig. 20). The most conspicuous feature of the nacre is the beautiful iridescence, an interference phenomenon due to the diffraction of light by the irregular free edges of the numerous delicate lamellæ, alternately calcareous and organic, of which the layer is formed. The iridescence in the case of the Ceylon shell is singularly brilliant, but the nacre is too thin to be of much value in the arts.

The markings on the interior of the shell (Plate IV.) consist of:—

(1) The large adductor impression sub-centrally placed and occupying from one-third to one-half the diameter of the shell; and

(2) The pallial line and scars caused by the insertion of the pallial muscles, which are fan-shaped bundles formed of fibres radiating outwards from small insertions placed along the pallial line. These insertion scars vary considerably both in number and in form. Usually there are from 12 to 15 between the umbonal region, where they begin anteriorly, and the antero-ventral end of the adductor, with 3 between the dorsal tip of the latter and the hinge line (see Plate IV., figs. 2 to 6). Besides these, which are distinct scars, there is an extremely narrow and practically continuous insertion band confluent with the posterior and ventral edge of the adductor scar. This band leaves no separate impress upon the nacreous surface of the valve, its scar, like that of the retractor muscle of the same side, being merged with that of the adductor (see Plate IV., fig. 1). Figs. 2 to 6 show five variations in the distribution of the insertion scars of the pallial muscles, while fig. 1 is the typical arrangement of the muscles as seen on removal of the valve.

As to the size of the Ceylon pearl oyster shell at different ages, we believe from our observations on different grounds that there may be very considerable variations according as the conditions are favourable or the reverse. It is difficult to get well-established dates fixing the ages, but the following figures may be useful as giving some indication.*

A pearl oyster in the Master Attendant's Office at Colombo, labelled by Captain DONNAN as being $2\frac{1}{2}$ years old, measures $3 \times 2\frac{3}{4}$ inches.

The average of the oldest pearl oyster from the Muttuvaratu Paar in March, 1902, also considered by Captain DONNAN to be $2\frac{1}{2}$ years old, is $2\frac{1}{4} \times 2$ inches.

A 1-year-old oyster, from the samples in the Master Attendant's Office, measures $2\frac{1}{8} \times 2$ inches.

Some natural-size drawings made by Dr. ONDAATJE many years ago, at Colombo, show the following sizes:—

1-year-old measures	2×2 inches.
2 ,, ,, ,, ...	$3 \times 2\frac{3}{4}$,,
3 ,, ,, ,, ...	$3\frac{1}{2} \times 3$,,

Mr. HORNELL is now measuring very large numbers of shells, and is determining more accurately than has yet been done the average growth year by year, and the results of his observations will appear in the final volume.

* See also the measurements and weights given in "Observations and Experiments on the Life-History and Habits of the Pearl Oyster," in Part I. of this Report, p. 136.

GENERAL ANATOMY.

Before describing the different systems of the body in detail, it may be well to refer to a few of the figures on the plates, which give some idea of the general structure and arrangement of the soft parts of the animal inside the shell.

Fig. 3 on Plate II. shows the left side of the animal when one valve of the shell has been removed; the dorsal surface is above and the anterior end to the left. In the centre is seen the single great adductor muscle (white) with the heart and viscera above it, the sickle-shaped gills (dark) curving round the lower central surface of the muscle, and the foot (at the base of the gills) with its byssus fibres projecting anteriorly (to the left). The mouth is above the byssus, and the anus on the ventro-posterior edge of the muscle where the anal funnel can be seen projecting (right-hand side of figure).

The three widely gaping specimens seen in fig. 5, A, B, C, show the adductor muscle in the middle crossing from valve to valve, the gills in the form of two lamellæ on each side and a mantle lobe or pallium lining each valve of the shell. The pigmented mantle-edge, studded with little papillæ or tentacles, is well seen in the left-hand specimen (A).

The diagrammatic dissections shown in figs. 1 and 2 on Plate VI. give the chief systems of the body in their relative positions. Fig. 1 shows mainly the course of the alimentary canal from the mouth (*O*) to the stomach (*St.*) and through the various parts of the intestine to the anus (at *An.f.*). Fig. 2 shows, in addition, the heart (*Au.* and *V.*) and the principal blood-vessels. The lettering of these figures in the Explanation of Plates will supply further information.

Finally, the series of sections through different parts of the body, given in Plate V., show the relations of gills to mantle lobes, of gills to foot, of adductor muscle to viscera, of stomach to liver, of intestine to heart, and so on. They need not be described here in detail, as a full account of each is given in the Explanation of the Plates.

PALLIUM OR MANTLE.

The integument or outer part of the body-wall forms two great lateral flaps, the right and left pallial or mantle lobes which line the valves of the shell and wall-in the pallial cavity—the space, freely open to the water when the shell gapes, into which the foot and the gills project (see the top row of sections on Plate V.). The two pallial lobes are separated anteriorly, ventrally, and posteriorly, but become continuous dorsally underneath the hinge-line of the shell. The free edge of the lobes is thickened, pigmented, and fringed with short branched tentacles (see Plate III., figs. 6 to 10). This pallial edge of the mantle is attached some little distance inside the margin of the shell, and the nacre stops short where the mantle is attached (see Plate II., fig. 6, where the mantle has been drawn back at one point to show the

nacre), and that is the point to which the mantle is retracted in preserved specimens, leaving the non-nacreous part of the valve exposed (see also text-fig. 1, where the pigmented mantle edge is drawn up on the left side of the figure to show the nacre).

The mantle has the same general structure as in other better-known Lamellibranchs, such as the European oyster, *Ostrea edulis*. It is composed mainly of connective-tissue traversed by muscular bundles and numerous blood spaces, and covered on both

Fig. 1. Dissection of pearl oyster from the right side, showing the stomach and digestive gland, the gills, foot and byssus, pigmented pallial margin, and a cyst-pearl *in situ* at the top left-hand corner; natural size, from a photograph by Mr. Hornell.

outer and inner faces by a layer of epithelial cells, the ectoderm (Plate VIII., fig. 2). The epithelium on the outer surface, next to the nacreous layer of the shell, is secretory, while on the inner free surface, facing the pallial cavity, the ectoderm is ciliated (Plate VIII., fig. 2, *i.ep.*). The centre and dorsal part of each pallial lobe is adherent to the rest of the body and thus envelops the viscera (Plate V., fig. 10, *Pall.*), while the ventral and marginal parts hang down freely like a flap or curtain, so as to form the side walls of the pallial cavity (see various sections on Plate V.).

Further details of the minute structure of the mantle are seen in fig. 2 on Plate VIII. The marginal and velar processes, the deep periostracal groove, the blood spaces, the glands, the muscles, and the nerves are all evident. The character of the epithelium in different parts is shown in the more highly magnified side figures:—A. shows the tall epithelium which secretes the prismatic layer; B. is the much lower general surface which deposits nacre; C. shows the ciliated internal surface; D. and E. the side and end of the marginal groove, with glands and high epithelium for the secretion of the periostracum.

Each pallial lobe may be divided into three parts, a central, a distal or muscular, and the marginal mantle-edge. The central pallial area extends from the mid-dorsal line to the pallial line (Plate IV., fig. 1), where the shell is marked with muscle scars. This part of the pallial lobe is perforated by the insertions of the adductor (*Add.*), the retractor (*Ret.*), the levator (*Lev.p.*, *Lev.a.*), and the pallial muscles. In a healthy condition of the living pearl oyster, the tissues of this part of the mantle are soft and mucoid in consistence, and opalescent white in colour. After hardening in alcohol this tissue becomes brittle, and has a semi-prismatic fracture which is very characteristic. All varieties of pearls—cyst, ampullar, and muscle pearls—may form within its substance. Text-fig. 1, p. 43, shows a cyst-pearl *in situ* close to the dorsal extremity of the adductor muscle.

The distal or muscular area is translucent, and is capable of considerable contraction by its muscles, and distention by the influx of blood into the large sinuses it contains. It is formed of a thick layer of loose connective-tissue traversed by nerves and blood-spaces, and by the radiating fan-like bundles of the pallial muscles (Plate VI., figs. 1 and 14, *Ret.Pall.*). This region is highly sensitive and irritable, and so contractile that we found it difficult to introduce even minute foreign bodies between the mantle-lobe and the shell in our experiments on artificial pearl-production.

The marginal region or mantle-edge is chiefly a muscular thickening which ends in two thin membranous folds with pigmented papillate edges (Plate II., figs. 3, 5, A, and text-fig. 1). The outer of these, bearing digitate papillæ, is in the same plane as the inner surface of the shell and forms the true pallial edge (Plate V., fig. 1, *Mg.Pall.*). The inner, which bears flattened palmate papillæ, and may be called the pallial veil or velum, projects inwards at right angles from the mantle-edge (Plate V., fig. 1, *Vel.*), so that the veil of the one pallial lobe stretches towards that of the other (Plate II., fig. 5, A). In life the free edges of the two veils are usually in contact along the median line of the body, except at two spots where they gape. One of these, the inhalent aperture, is somewhere about the middle of the ventral surface; while the other, the exhalent, is at the posterior end, opposite the opening of the anal funnel and supra-branchial chamber. The former is not a permanently localised or specialised opening, its position and its size and shape vary considerably from time to time, so that any part of the ventral edge may form temporarily the inhalent gap through which the main in-flowing current passes. The exhalent aperture, on the contrary, is definitely localised and specialised. In outline it is broadly ovoid or almost circular (Plate III., fig. 10). Its broad rounded lower (ventral) margin is immediately dorsal to the pallial fold, an inwardly directed gutter-like fold of the velar margin that meets the tip of the ctenidium (see Plate VI., figs. 1, 2, &c., *Pall.f.*).

In 3 to 4-year old oysters the velum has a breadth of fully $\frac{1}{4}$ inch on the ventral aspect where it is most fully developed. Here, too, the marginal processes are largest, and are of two kinds, long and short, several of the latter usually alternating with the singly placed longer (Plate III., fig. 6). Diversity of form in the larger ones is

great, no two being quite alike, but most of them are doubly trifid, the summit of the papilla being first divided into 3 stout branches, each of which again divides into 3 digitate twigs; occasionally a twin process is seen (fig. 7). The extremities of the twigs bear minute (? sensory) processes formed of groups of epithelial cells.

In a healthy expanded oyster, where the papillate edges of the velum meet, these large papillæ interdigitate (Plate III., fig. 10). The short papillæ, which are placed between, are simpler, and digitate in form.

Along the posterior edge of the body, *i.e.*, from the pallial fold upwards to the posterior end of the hinge, the larger papillæ of the veil become greatly reduced in size and simpler in form until, in the region of the posterior "auricle" of the shell, they approach in character those of the pallial margin. The same reduction in size is also seen in the velar processes within the anterior auricle.

The pallial margin consists of a conspicuously pigmented papillate free inner edge and an outer fold, which is continuous with, and is covered by, the film of periostracum which folds over the free edge of the valve (Plate VIII., fig. 2, *Mg.Pall.* and *Per.Ostr.*). The whole of the free margin is drawn out into very delicate and very sensitive elongate digitate processes of two sizes, long and short (Plate III., fig. 8). In young specimens, 1 year old, the tips of the longer papillæ bear asymmetrically disposed secondary projections, sometimes simple, sometimes very abbreviated. In older individuals—2 years old and upwards—these longer papillæ become further elongated and conspicuously fimbriated (Plate III., fig. 9). They can be seen, when alive, swaying and bending gracefully about as if the tip were a tactile organ on watch, feeling first in one direction, then in another. These finger-like processes are especially well developed in the region of the exhalent aperture—some, a full $\frac{1}{4}$ inch in length, projecting even beyond the velar papillæ, which latter are here turned outwards in the same plane as the mantle lobe. The long processes stand singly, separated from one another by from 2 to 11 short and usually simple digitate papillæ closely set (Plate III., fig. 8). The appearance of the surface of a papilla in section is shown in Plate VIII., fig. 2, at *Mg.Pall.*

The Ciliated Pallial Path.—The whole of the inner surface of the pallial lobes is ciliated, but, at the ventral truncate edge of the labial palps, a specially marked ciliated path begins which, curving at once outwards and downwards, passes to the base of the velum, parallel with which it runs until it reaches the anterior wall of the pallial fold, where it passes over the velar edge by means of a slight folding of the latter (*Pall.f.*, Plate VI., fig. 14). The cilia of this pathway are in continuous action from before backwards, by which means the unsuitable particles collected by the gills and sent forward to and rejected by the palps are conveyed away and passed out from this pallial fold (Plate VI., figs. 1, 15, &c., *Pall.f.*).

When coming under the influence of the strong excurrent flow from the gills, the smaller particles are frequently propelled to a considerable distance from the oyster—a provision to ensure that they do not again become a source of annoyance and loss

of energy to the animal. This provision for thus disposing of unsuitable particles is especially useful when the water is disturbed and laden with sand or mud. Under such circumstances the oyster feeds slowly, rejecting nearly everything that comes. When, as happened sometimes in our tanks at the Galle Marine Laboratory, the in-flowing water was laden with decaying vegetable *débris* in great quantity, or when mud was present, the palps accumulated the particles till they had enough to form a small bolus. This while forming was revolved constantly by the palpar surfaces. When large enough, a twist seemed to be given to it whereby it passed from the palps to the anterior end of the pallial ciliated path, along which it advanced rapidly, and was shot out in a few seconds. In the course of a few hours it has been noticed, when the tank water remained still, that a conical pile of ejecta more than $\frac{1}{4}$ inch high accumulated on the ground just behind the oyster (Plate VI., fig. 14, *Pel.*).

Pigmentation.—The free pallial margin together with the velum is in most cases deeply pigmented (Plate II., figs. 3, 6), usually in black, grey, and shades of yellows and browns, mostly chestnut brown, though orange is also frequent. The pigmentation is usually in the form of large alternate blotches which give a certain appearance of regularity to the colouring; but the exact pattern varies much. It is noticeable, however, that there is considerable difference in the degree of pigmentation in oysters from quite shallow water and in those from depths of 6 to 10 fathoms. The latter have the colouring mainly confined to the velum and the pallial margin, whereas in the former the pigment may extend widely over the general inner face of the mantle. We find that orange and chestnut tints are much more frequent amongst the pearl oysters of Trincomalee Harbour, which live in shallows averaging from 6 to 18 inches at low tide, than amongst those from the deeper banks in the Gulf of Manaar. The gills also are more frequently and more extensively pigmented at Trincomalee than amongst individuals from deeper water.

THE FOOT AND BYSSAL ORGAN.

The Foot is a highly mobile tongue-shaped organ capable of great elongation and contraction. It arises from the anterior region of the visceral mass nearly midway between the mouth and the intestinal lobe and has the anterior extremities of the branchiæ flanking it on either side (Plate VI., fig. 1). The greater part of its bulk is composed of networks of muscle fibres running in various directions, thus ensuring a wide range of movement, and is so extensively penetrated by blood spaces that the organ is highly cavernous. When these spaces are rendered turgid through an influx of blood, the foot becomes erected and is then quite three times as long as in the completely contracted, non-turgid state. In the latter condition it has the form of a slender elongated cone tapering gently from a wide base to a pointed apex (Plate III., fig. 13). The dorsal and ventral surfaces are clearly distinguishable, the former convex in section; the latter, which is grooved longitudinally, is also convex in

section when in a state of contraction (Plate III., fig. 21). It becomes flattened in the distal third when the organ is extended (fig. 20). In oysters of 2 years of age and upwards the dorsal surface and the sides of the foot are usually so thickly covered with dark chestnut pigment speckles as to appear quite brown. The speckles become less numerous on the lower parts of the sides as they approach the prominent white edges of the ventral or pedal groove, while the floor of the locomotor or anterior part of the pedal groove is usually pigmented similarly to the exposed part of the foot. Occasionally the pigment is purplish-brown, dark drab, or even dark orange.

The foot in 3-year-old oysters is capable of extension to over $1\frac{1}{2}$ inches when fully turgid; in contraction the length is $\frac{1}{2}$ inch or even less. In an older oyster it may be extended to over 2 inches. Oysters 6 to 9 months old can extend the foot to a length of 1 inch, contracting it to about $\frac{1}{3}$ of an inch.

A deep pouch-like pit, the byssus gland or organ, is lodged at the proximal end of the foot upon the ventral aspect. The wide mouth of the pit (Plate III, figs. 13, 14, 15, 22, &c.) is a little way anterior to the junction of the foot with the visceral mass, while the pouch itself penetrates deeply backwards and slightly downwards into the central portion of the visceral mass (Plate VI., fig. 2). The axis of the mouth of the byssal gland coincides with the longitudinal axis of the foot. The byssal gland lodges the common "root" of a bundle of stout, laterally-flattened, bronze-green fibres, the byssus, which by means of a discoid attachment at the distal extremity of each fibre anchors the pearl oysters to rocks and other objects (Plate III., figs. 16, 22, 22, 23). The anterior edge of the mouth of the byssal gland passes into a groove, the pedal groove, extending medially along the whole of the remaining length of the ventral surface of the foot (Plate III., fig. 20, and Plate VIII., figs. 3 and 4).

The pedal groove comprises two regions functionally distinct, a distal or locomotor and a proximal or secretory. Both are, indeed, lined with a layer of secreting glands, but while this layer is of great thickness in the proximal region, in the distal it is thin, and the secretion is of a different character (Plate VIII., figs. 3, 4). When the foot is contracted, the edges of all parts of the pedal groove are approximated.

The hinder or secretory part of the groove has two regions, an anterior part which is cup-shaped when in use, and a hinder which is nearly always tubular through the approximation of the lips of the groove. The anterior cup-shaped part is about mid-way between the base and the tip of the foot, and may be termed the "disc-pit." The tubular byssal groove connects this with the byssal gland. Figs. 3 and 4, on Plate VIII., represent the structure of the foot as seen in transverse section; both show the numerous muscle bundles, longitudinal, circular, and oblique; fig. 3 has the open locomotor pedal groove ventrally, and fig. 4 the closed byssal groove which becomes an open canal further out.

Functions of the Foot.—The functions of the foot are threefold: the distal ventral surface subserves locomotion; the median and posterior parts effect attachment by

means of the secretion of the byssal fibres; lastly, on account of the general mobility of the organ, and probably its sensory nature, the tip is of great use in cleaning the gills and mantle from intrusive particles that cannot otherwise be got rid of.

Locomotion.—As has been explained in this Report, Part I., the pearl oyster is capable of travelling short distances when it is freed from the byssal cable which attaches it to some foreign body. When separated either by the byssus being wrenched away, as may happen in diving operations or in dredging for transplantation, or by its own action in sloughing the root of the byssus, it soon, under favourable conditions, extends the foot as far beyond the shell as possible and begins to travel. The tip of the foot circles round, bending first in one direction and then in another, till it meets a body suitable for crawling upon. Then the groove immediately behind the tip opens (see Plate III., figs. 18 and 19) and is flattened against the surface selected, whereupon progression takes place by alternate extension and contraction, as seen in the crawling action of the typical gastropod foot. Only that part of the pedal groove anterior to the disc-pit takes part in the locomotion, an action therefore strictly limited to the distal third of the organ.

Cleansing.—As to the use of the foot in freeing the gills, palps, and mantle from intrusive bodies, it can be seen through the partly open valves of a living oyster that the point is pushed between the gill plates, and over the inner surface of the mantle, gently stroking the surface and insinuating itself into the crevices, thus freeing the parts from any foreign bodies—accumulations of *débris*, &c.—that might cause inconvenience. It is frequently on the move in this manner; when at rest, it lies shortened up, with the tip turned to the left, and tucked downwards between the left gill and the mantle. In one pearl oyster, in which Mr. Hornell had broken a hole in the umbonal region of the valve, the mantle beneath being also pierced, the foot was seen feeling gently round the edges of the wound and working off particles of dirt that had gathered. The tongue-like tip was passed occasionally *through* the wound in the mantle and projected somewhat, at one time well beyond the hole in the valve. The tip also freed the wound from dirt lying between the mantle and the valve.

Attachment by the Byssus.—When a pearl oyster finds a place to re-attach to, subsequent to sloughing a former byssus, it uses the locomotor region of the tip as a suctorial organ to hold its body in position, while at the same time the disc-cup expands and its edges press against the attachment surface, and the edges of the byssal groove are tightly closed against one another. While in this position, the byssal gland pours forth through the byssal groove a quantity of a fluid secretion which has the property of coagulating and hardening upon contact with sea-water. This secretion sets in a remarkably short time, and usually after the foot has remained pressed to the contact surface for between 3 and 5 minutes, it is withdrawn and then reveals the presence of a pale yellow, elastic strand stretching from the mouth of the byssal gland to the point where it is attached by an oval disc, which is a model of the cavity of the

disc-pit. During the withdrawal of the foot the edges of the byssal groove open to permit of the newly-formed byssal fibre passing out. Under favourable conditions this operation is performed again and again, until at last from 50 to 70 fibres are formed, constituting a wonderfully strong cable of attachment. In 3-year-old oysters the byssus is so strong that the twist and wrench necessary to break it off requires a distinct effort. The divers dislike fishing pearl oysters which are attached individually to rocky surfaces, as the effort of wrenching them off reduces the result of the day's work both by taking longer time and also because of the weariness induced by the hardness of the work. After a few days' fishing on a rocky bank the divers' hands become painfully lacerated unless they take the precaution, as many do now, of using roughly made gloves. From the age of 4 to 5 years the strength of the byssus decreases, rendering the older oysters more easy of detachment.

Structure of the Byssus.—On examining a sloughed byssus we find that the individual fibres arise from an ovate, laterally compressed "root" (Plate III., fig. 23; sometimes it is forked with laterally spreading groups of fibres), the surface whereof is corrugated or laminated in correspondence with the parallel folding or grooving, which is characteristic of the inner surface of the walls of the byssal gland (Plate VIII., fig. 5). This mass can be resolved into branched or pennate fibres, the twigs of which penetrate between the lamellæ of the gland and come into close relation with the surrounding muscle bundles. Each byssus fibre, outside the body, is distinctly flattened laterally, and can be readily frayed into a number of longitudinal fibrils. Each terminates distally in an oval disc by which attachment is made to rocks, old oysters, and other suitable bodies. The fibres are of a lustrous deep bronze-green colour, growing paler as they enter the root. When first formed, however, they are pale yellow, gradually becoming of the characteristic green tint in the course of the ensuing 48 hours.

The byssus is markedly elastic and very tough, and the disc is so firmly attached that if sufficient tension is applied either the substance to which the disc adheres gives way or the strands themselves break. It is a most rare occurrence for the "root" to be torn out—a fact that is of the greatest importance in the cultivation by transplantation of the pearl oyster, as otherwise the pearl oysters dredged for transplantation would be so injured during the operation that death would ensue in the majority of cases. As it is, the wrenching off of pearl oysters is found in practice to induce no ill effects. An hour afterwards, under favourable and natural conditions, the pearl oyster begins to slough the root of the ruptured byssus and may, indeed, actually make re-attachment by means of a new byssus within this period.

The approximated ends of the two retractor muscles are attached to the hinder end of the byssal gland (Plate III., fig. 24, *Ret.*). The structure of the byssus gland, as seen in section, is shown in fig. 5 on Plate VIII. It is divided into two halves, placed right and left, and each formed of parallel layers of glands opening into narrow folds, in which the secretion forms long, and in places convoluted, threads. The byssus

fibre is a compound structure formed by the union of a number of these threads of secretion. The figure shows a few of the narrow folds from one side only, the glands, the convoluted threads of secretion and the close relation with groups of muscle fibres on the periphery of the organ.

THE MUSCULATURE.

The pearl oyster is monomyary, possessing a single adductor (the posterior), the largest and most important muscle in the body. The other muscles present are :—one pair of retractors of the foot, two pairs of weak pedal levator muscles (superior retractors), the orbicular retractor muscle of the mantle (pallial muscles), the intrinsic muscles of the foot and visceral mass, the branchial bands, and the heart or cardiac muscle (which will be discussed under the vascular system below).

The Adductor Muscle of the shell (*Add.*, Plate VI., fig. 1) stretches transversely across the body from valve to valve. It is a massive bundle, wedge-shaped in section, and slightly curved (Plate II., figs. 3, 4). The narrow end points upwards and lies immediately behind the ventricle of the heart. The terminal part of the rectum runs in the middle line along the posterior surface (Plate VI., fig. 1, *Int.* 3).

As the concavity of the muscle faces upwards and forwards, the wider ventral end, which is rounded, is turned anteriorly. Its anterior margin marks, approximately, the centre of each valve, while the dorsal and posterior apex lies a short distance in front of the posterior sinus in the margin of the shell. Thus, as the lower end of the adductor stretches from side to side in the widest region of the body, the fibres decrease in length as they approach the dorsal and posterior extremity, where the extent of the muscle is less by half than at the anterior and ventral end.

The muscle is not homogeneous; two distinct regions are obvious. The one, a narrow tendinous strip made up of white glistening fibres, forms the posterior border (*Add.'*, Plate VI., fig. 1, and sections on Plate V.); the other, broad and massive, of colourless, semi-translucent fibres, occupies the remainder of the mass. Under the microscope, the fibres of the latter are finer when teased up, and have an appearance which has been described as striation, but is by no means distinct;* those of the former are about two to three times as thick, more fleshy and quite smooth.

The substance of this muscle is permeated with lacunar spaces, penetrating into and among the loosely compacted bundles of fibres. The blood supply is derived from the posterior pallial arteries which arise from the terminal branches of the posterior aorta and pass outwards to the mantle sunk within the substance of the tendinous portion of the adductor (*Art.p.p.*, Plate VII., fig. 4).

The power exerted by the adductor in bringing the two valves together by its contraction is very considerable, and the action is very rapid. Sir WILLIAM TWYNAM

* Very much less obvious than the striation of the corresponding fibres in, for example, *Pecten opercularis*.

relates ('Report on Ceylon Pearl Fisheries,' p. 6, 1900) how at the fishery ot 1891, after the oysters had been landed and had lain in heaps in the Kottu for some time, one gaping individual had still strength enough left to snap at and seize a hungry sparrow which incautiously attempted to feed upon it. The oyster held on so tightly that all the efforts of the trapped bird to escape were vain, and the strangely assorted pair are now to be seen in Sir William Twynam's museum at Jaffna. Similarly, Mr. Hornell reports that an oyster lying in the Kottu during the last fishery (1903) captured a mouse (now in the possession of the Lieutenant-Governor the Honourable Mr. E. im Thurn); and that he himself saw the foot of that agile animal, an inquisitive mongoose, caught by an oyster which resisted all the efforts made to dislodge it for nearly five minutes.

Although the pearl oyster has not the power of moving rapidly through the water or over the sea-bottom after the fashion of *Lima* and of some species of *Pecten*, by the violent expulsion of water caused by a sudden closure of the valves, still it can eject a jet of water with some force to a distance of 9 to 12 inches, as can be seen when living oysters are watched in shallow vessels of water. This forcible ejection is evidently useful in dislodging any small animals and other particles that may have gained access to the branchial chamber.

The Retractors of the foot are a pair of symmetrically disposed muscles lying in the horizontal plane of the body. They originate (*Ret.*, Plate III., figs. 24, 25) in the walls of the byssal gland and, then diverging, pass backwards in V-like manner, to be inserted, one into the right valve, the other into the left, within the concavity of the adductor scar (compare *Ret.* on Plate IV., fig. 1, with other figures on same plate). Neither retractor impresses a separate scar upon the nacre, the posterior edge of the retractor impression blending indistinguishably with the anterior edge of that of the adductor.

In its anterior portion each retractor is sub-cylindrical, flattening to an oval, in section, at the place of insertion. There is no decussation of the fibres of the two bundles at their junction anteriorly.

The Levators of the foot are four, two anterior and two posterior. Each of the anterior pair (*Lev.a.*, Plate III., fig. 26) has its insertion at the apex or inmost point of the umbonal recess of its respective valve—a point directly dorsal to the mouth region. From this place the fibres pass vertically downwards, on either side of the mouth, spreading laterally, fan-like, as they go. The external lateral fibres eventually blend with the muscular sheath on the sides of the viscero-pedal mass, while the inner or anterior fibres pass into the root of the foot.

The left anterior levator is considerably stronger than its neighbour, a specially strong cord of fibres passing on the inner side to the dorsal aspect of the root of the foot. By the contraction of this cord the foot is drawn over to the left side, which is its normal position when in a state of rest. The explanation of this asymmetrical arrangement is seen in the fact that the left valve is much deeper and consequently

more roomy than the right, and so the foot is more easily accommodated on that side of the body (as shown in Plate II., fig. 6).

The posterior pedal levators (*Lev.p.*, Plate III., fig. 26) are two short insignificant bundles which originate high up in the fibres of the anterior levators, exactly on the level of the mouth. Thence their course is backwards and upwards through the visceral mass to an attachment to the valves behind the scar of the corresponding anterior levator, but on a slightly lower plane. The whole course of each posterior levator in an adult oyster is less than one-quarter of an inch—from $\frac{3}{16}''$ to $\frac{1}{4}''$. The contraction of the anterior levators causes the foot to be retracted and raised dorsally; the coincident shortening of the posterior levators introduces a drag towards the rear. No protractor muscles are present, turgescence of the venous pedal spaces effecting, in the main, the protrusion of the foot when muscular relaxation takes place.

The Intrinsic Muscles of the foot and viscera are diffuse rather than in masses. Those of the foot form a muscular enveloping sheath or interlacing net of considerable thickness and complexity. It is formed of several ill-defined layers and scattered bundles, shown in transverse section on Plate VIII., figs. 3 and 4. A number of the internal bundles run in the main longitudinally along the foot, some fibres run circularly, there are groups diverging radially, and in some parts the fibres interlace in various directions.

In the visceral mass proper, small transverse muscle bundles pass from side to side, binding its tissues together and providing a framework, slight though it be, wherein ramify the tubules of the digestive gland and of the gonads. These transverse intrinsic bundles are somewhat spindle-shaped, each end narrowing to a tendinous insertion attached to the fibrous connective-tissue ensheathing the visceral mass.

Of other intrinsic muscles the most important are the branchial, one of which, in the form of a flat band of muscle fibres, runs within each ctenidial axis from end to end, close to the dorsal edge, along with a large nerve. These bands have the effect of retractor muscles, shortening the gills and withdrawing their posterior extremities, an action assisted by other muscle fibres which radiate, fan-like, from a point just in front of the anterior margin of the adductor. There are also muscle bundles running longitudinally down each side of the principal filaments (Plate VIII., fig. 13, *m.b.*).

The Pallial Muscles (*Ret.pall.*, Plate VI., fig. 14) are all retractors, and together constitute the orbicular muscle of the mantle. They are a series of fan-shaped muscles, radiating outwards to the mantle edge from a number (15 to 18) of insertion centres of various sizes, arranged circularly, and which together form the well-marked pallial line of scars that runs parallel with the margin of the shell, upon the inner surface of each valve (Plate IV., figs. 1 to 6). The fibres lie entirely within the layer of loose connective-tissue, that is between the inner and outer epithelial surfaces of the free portion of the mantle. Their ultimate ramifications form an anastomosing network, the branches diverging and reuniting in the complex manner seen in Plate VII., fig. 13. The bundles in some cases surround the branches of the pallial nerves.

With the exception of the heart, and the somewhat indistinct appearance of striation in the larger portion of the adductor, the muscle fibres throughout the body are non-striped.

THE ALIMENTARY CANAL.

As the œsophagus and the stomach, together with two-thirds of the intestine, lie within the viscero-pedal mass (see Plate VI., fig. 1), the surrounding tissues, first those of the superficially placed gonad and then of the more deeply lying digestive gland have to be carefully picked away before the relative positions and the course of the parts can be traced. Hardened material is easier to manipulate than fresh ; and the best method is to kill the animal by immersion in a 5-per cent. aqueous solution of formol, and to keep it therein till the day prior to dissection, when it should be removed from the shell and soaked in several changes of fresh water to remove most of the formol.

Two projecting horizontal lips conceal the aperture of the mouth (*O.*, Plate VI., fig. 1). Each is smooth on both outer and inner surfaces, and is produced laterally at each extremity into a labial palp, the upper lip passing right and left into the right and left dorsal palps, and the lower into the corresponding ventral palps (*Pa.*, in various sections on Plate V.). The palps are smooth on the surfaces turned away from the mouth, but are closely grooved on the opposed faces which bound the entrance to the mouth. The mouth thus guarded lies at the base of the deep cleft formed by the approximation of these lips. It is a large, slit-like depression placed transversely between the anterior levator muscles of the foot. Each of the two corners or angles of the mouth is produced laterally to merge imperceptibly into the palpar gutter that marks the line of junction of the dorsal and ventral palps of that side. In this way a long shallow ciliated gutter leads up to each angle of the mouth from between the palps.

The oral cavity rapidly contracts inwards to the narrower width of the œsophagus (*Oe.*, Plate VI., fig. 1), which is a short, straight, ciliated tube, dorso-ventrally compressed, continued posteriorly along the median line and in the same plane as the mouth. Its hinder end opens into the anterior end of the stomach, slightly below the level of the roof.

The form of the stomach (*St.*, Plate VI., fig. 1) is ovoid, the long axis lying horizontally, with the narrow end directed anteriorly and slightly upwards. It is unsymmetrically placed, encroaching greatly upon the left portion of the visceral mass—so much so that three-fourths of its capacious chamber lies to the left of the median plane. Except at the extreme left, and for a small space on the roof, it is enveloped by the digestive gland.

Folds and depressions diversify the walls and floor of the stomach and break them up into definite areas. The most conspicuous is a slightly projecting vertical fold which arises from the posterior wall and from the hinder part of the floor, marking

out the hinder or cardiac moiety of the stomach into a right and a left chamber. This postero-ventral fold (*P.v.f.*, Plate VI., fig. 7) dies away before reaching the roof, which, in marked contrast to the rugose floor, is smooth and unbroken, except for a small but well-marked median depression or pit at the junction of the anterior with the median third. The wide bipartite opening into the intestine and intestinal cæcum (*Int.ap.*, Plate VI., fig. 7) marks the hinder end of the floor of the left chamber, which may therefore be named the intestinal or pyloric chamber. In size it slightly exceeds the right or cæcal chamber, the former being appreciably deeper, and being as wide as it is deep, whereas the height of the latter is twice as great as its breadth (Plate VI., fig. 4). Anterior to where the postero-ventral fold dies away midway along the floor, a peculiar flattened and obliquely sloping plate (*Pl.d.*, Plate VI., fig. 7), facing backwards, upwards, and to the right, occupies a sub-central position; and branching channels radiate forwards on its surface, connected possibly with the distribution of the digestive fluid. To the right of this area, which may be named the dendritic plate, is a ridge with accompanying furrow, running forwards and upwards to the antero-lateral bile-duct, while to the left is a shallow, wide pre-intestinal depression (*P.i.dep.*, Plate VI., fig. 7). A deep, rugose, sub-œsophageal pit (*S.œ.p.*) is well marked anterior to the dendritic plate, and high up on the right lateral wall the postero-lateral furrow leads from the postero-lateral duct towards the intestinal aperture. On the left side, a stout antero-lateral fold lies between the pre-intestinal depression and the sub-œsophageal pit.

The digestive gland, or "liver" (*D.gl.*, Plate VI., fig. 1), as already noted, surrounds the stomach except at small areas upon the extreme dorsal and right lateral aspects. Under healthy conditions it is of large size and of a characteristic deep sage-green colour. It is made up of dense clusters of secreting alveoli (Plate IX., fig. 3), which open into ductules and thence into the larger ducts, which lead into the stomach. There are eleven of these terminal ducts, namely :—

a. The *antero-lateral duct* (*D.a.l.*, Plate VI., fig. 6), opening high up on the right side, and posterior to the right of the sub-œsophageal pit.

b. The *postero-lateral duct* (*D.p.l.*, fig. 6), opening at the same level and on the same side, within the posterior third of the stomach. Several large ductules open at its very end (as is the case with *a* and several of the others), and, as the latter is wide, some of these tributary apertures are visible from within the stomach. This duct ramifies within the upper and posterior region of the digestive gland.

c. The *postero-ventral duct* (*D.p.v.*, fig. 7) opens in the floor of the posterior third, also upon the right side. It comes from the posterior and ventral parts of the gland.

d. Anterior to the last named are the *three sub-central ducts* (*D.s.c.*, fig. 7), the inmost one being of large size.

e. *Two pre-intestinal ducts* open within the pre-intestinal depression and drain the left ventral portion of the gland.

f. Below the œsophageal aperture the openings of three small *sub-œsophageal ducts* (*D.s.œ.*, fig. 7) can be readily made out, bringing the secretion of the anterior and lower portion of the glandular organ.

To see the openings of these ducts, divide the stomach horizontally along the mid-lateral plane and syringe out the contents. Then *a* and *b* will be seen upon the right side of the roof (see fig. 6), the remainder upon the ventral half (fig. 7). The course of the larger ducts can also be traced for some distance by picking away the glandular tissue around the stomach (see also figs. 8 and 9).

Lining the greater portion of the gastric cavity, dipping into depressions and rising over the folds, a gelatinous layer (corresponding to the "flèche tricuspide" of some other molluscs) invests the epithelial lining. It is colourless and transparent; and in section is seen, under the microscope, to be a cuticular laminated structure in close relation with the underlying epithelium. In freshly caught, healthy individuals, the distal end of the crystalline style is invariably seen protruding into the stomach from the circular and larger anterior portion of the intestinal aperture.

The intestine may be divided into three sections of approximately equal length, namely: (*a*) The descending portion; (*b*) the ascending portion; and (*c*) the rectum (see Plate VI., fig. 1).

(*a*) The first or descending section of the intestine (*Int.* 1) passes ventrally, with a slight inclination to the rear, into and through the posterior part of the visceral mass, which is here composed of the tubules of the gonad. Its course then lies behind the base of the byssal gland and between the converging bundles of the two pedal retractor muscles. At this point it changes its direction and curves forwards and downwards to the prominent antero-ventral corner of the visceral mass which marks the point of its junction with the ascending branch (*Int.*, 2).

A longitudinal fold projects inwards from the anterior and one from the posterior wall of the descending intestine. As these folds are *vis-à-vis* and to one side of the median axis of the tube, they divide it into two unequal longitudinal chambers, or rather gutters, that to the left being the larger (Plate VI., fig. 10, *a*). The two folds are low and little prominent for a short distance from the stomach; little by little they reach further across the cavity till in the middle and lower thirds their apices broaden and close together, so as to form two distinct tubes. The broader of the two is circular in section at all points; the smaller, except at the beginning, is irregular in sectional outline and appears rather as a narrow and deep gutter along the side of the broad cylindrical left portion (Plate VI., fig. 10, *b*).

The narrow tube usually contains a train of partially digested food matter, while under healthy conditions the larger cavity is completely filled with a clear gelatinous solid cylinder, the crystalline style, a gently tapering, pliant and slightly elastic rod. The right-hand tube, in spite of its insignificant diameter, is the true intestine, the wider left being the sheath of the crystalline style, which here, as in *Ostrea*, *Pecten*, *Cardium* and *Mya*, is imperfectly separated from the anterior portion of

intestine, with which it communicates by a longitudinal cleft. The function of the crystalline style is still doubtful. Among more modern views, while Möbius, Haseloff, and Hazay have argued that it represents a reserve food supply, Barrois, Pelseneer, and others believe it to function as a lubricant to obviate the danger of sharp fragments, taken in with the food, causing damage to the delicate lining of the intestine. The upper end of the style certainly projects into the stomach, and as it wastes, the hinder part is continuously being pushed upwards to compensate for the loss. According to Barrois, sand and shell fragments are invested by the viscous waste of the style, and so made bolus-like are moved along the intestine more freely and without inflicting injury upon the walls.

Margaritifera vulgaris is, however, capable of exercising a certain degree of selection in feeding, and sand grains are seldom seen in any numbers within the alimentary canal. And yet the crystalline style is always present in healthy individuals containing a fair amount of food material in the intestine, as, for example, all the individuals examined in Trincomalee harbour in October, 1902, and upon the Pearl Banks during the 1903 fishery. But out of 43 oysters examined at Galle during June, July, and August, while in a state of semi-starvation, having been kept for ten days and upwards in water containing little suitable food matter, five only showed a crystalline style. The alimentary canal of the whole number contained an extremely small amount of food, and the visceral mass was notably shrunken.

Still it must be remembered that small sand grains and sharp-pointed sponge-spicules and diatoms are here and there to be met with in the stomach contents, and in these cases the suggested gelatinous investment by the style would be useful. Moreover, the cohesion of particles into a bolus capable of traversing the intestine more readily, brought about by the investment, would, no doubt, also be useful.

A valvular folding of the intestinal ridges gives entrance to the ascending region of the intestine (*Int.*, 2, Plate VI., fig. 1), which, however, before turning on an upward course, curves backwards along the base of the visceral mass to the left of and parallel with the lower or forwardly directed portion of the descending intestine. At the posterior extremity of the ventral surface of the visceral mass the two intestinal divisions intersect, the ascending section crossing to the right. The intestinal loop (*Int.lp.*, Plate VI., fig. 3) thus formed in the floor of the visceral mass is the visceral loop. From the point of intersection the ascending intestine turns sharply upwards, running parallel with and closely adjacent to the upper part of the descending intestine, the course of the latter lying a little forward and to the left. The portion of the ascending intestine forming the second limb of the visceral loop is small in diameter and somewhat compressed. The anterior fold of the descending intestine is continued into it as a somewhat undulating and irregular dorsal ridge dying off midway along.

At the point where this division of the intestine assumes a dorsal course, an increase takes place in the diameter, concurrent with the appearance of a great longitudinal

fold, the *typhlosole* (Plate VI., figs. 3 and 11, *Ty.*) projecting inwards. At its start, this typhlosole projects from the anterior wall, but almost at once curves over to the posterior side of the tube, thence running vertically upwards without further change of course. Longitudinal and somewhat oblique furrows channel the surface, and as it expands greatly above the line of attachment to the intestinal wall, its bulk largely fills the cavity of the intestine. In transverse section, the lumen is seen to be reduced to an attenuate long-horned crescent (Plate VI., fig. 5). As it approaches the level of the floor of the stomach, the typhlosole thins down rapidly to a low ridge, and the intestine itself then curves posteriorly in the direction of the heart (Plate VI., fig. 1). This change in direction and thinning down of the typhlosole indicate the commencement of the rectum (*Int.*3, Plate VI., fig. 1), which is not marked by any other definite sign.

From the right-angled curve made by the intestine posterior to the stomach, the rectum runs posteriorly, through the upper part of the pericardium. Beyond this it begins to curve ventrally, and passes round the posterior aspect of the adductor muscle in the median line, ending in an erectile ear-like process bearing the anus (Plate VI., fig. 1), and situated opposite the exhalent orifice of the mantle.

The rectal typhlosole, though well-marked as a semi-cylindrical ridge (Plate VI., fig. 12, *Ty.*), never rises much above the semi-diameter of the tube. It runs along the intestinal floor while in the cardiac region, and when the rectum courses behind the adductor muscle it becomes a median fold on the anterior wall.

Where the first portion of the rectum passes through the narrow upper part of the pericardium, it has the ventricle attached to its lower surface (Plate VI., fig. 1) with an anterior aorta running forwards and upwards to the left, and a posterior aorta passing backwards posteriorly and ventrally to pursue a course parallel with the rectum (see also Plate VII., fig. 2). From the point where it passes from the cardiac region, the rectum and the accompanying aorta are overlaid with a considerable thickness of spongy lacunar tissue (Plate IX., fig. 6). The bulk thus attained renders the course of this division of the intestine conspicuous as a massive semi-cylindrical vertical ridge descending the posterior surface of the adductor in the median line. This rectal ridge (*R.r.*, Plate VI., fig. 15) is frequently pigmented with splashes of black and opaque white pigments—occasionally it is suffused more or less extensively with orange. Figs. 6 and 7 on Plate IX. show the range in height and shape of the rectal ridge, and fig. 8 gives the character of the tall ciliated epithelium of the rectum.

The anal process (*An.f.*, Plate VI., fig. 3) is a comparatively large, slightly curved, erectile, ear-shaped organ facing ventrally. It stands out at right angles to the last section of the rectum, and the tip is directed posteriorly, while the margins tend to be somewhat in-curved. The anal aperture (*an.*) is situated at the base, on the ventral aspect. Fæcal matter is expelled periodically in string-like masses, which, caught up by the steady exhalent current, are swept out through the mantle orifice and carried some little distance clear of the animal (Plate VI., fig. 14, *Pel.*).

The form of the anal process is likely to prove of diagnostic importance in the characterization of species when a revision of the genus *Margaritifera* and allied forms is undertaken upon the basis of a study of the soft parts. The variations in the shells of *M. vulgaris*, which our plates exhibit, show that such characters alone are insufficient for an accurate differentiation of some species.

The one living *M. margaritifera*, Linn. ("Black-lip"), which we had an opportunity of examining in Ceylon had an anal process wholly different from that of *M. vulgaris*, being pinnatifid palmate, with five lobes (Plate III., fig. 5).

In a third species, small and much flattened, which appears to be closely related to the Shark's Bay shell, this process is simple, as in *M. vulgaris*, but is broader in proportion, and with a rounded obtuse free termination, whereas in the latter it is longer and more lanceolate, with an acuminate tip (see Plate III., figs. 1 and 3). But probable variations in the soft parts must also be considered.

The histology of the wall of the alimentary canal is shown in figs. 8, 9, and 10, on Plate IX. The tube is lined by ciliated columnar epithelium throughout, and presents no features that call for special detailed description. The columnar cells on some parts of the wall are enormously taller than on other parts (see fig. 9), so as to form great pads projecting into the lumen. The ciliated epithelium of the stomach is continued for some distance along the larger ducts of the digestive gland (fig. 2).

The cæca of the digestive gland are seen cut in various directions in figs. 1 and 2 on Plate IX. In a transverse section the exterior of the cæcum is circular, but the lumen is frequently quadrangular (fig. 4) because of the unequal size of the gland cells. The organ agrees in detailed structure (see Plate IX., figs. 1 to 4) with that of other better-known Lamellibranchs, such as the common oyster.

THE BRANCHIÆ.

Between the slightly opened valves of a living pearl oyster the four sickle-shaped branchiæ or gills, delicately fluted and usually more or less edged and dappled with shades of grey and drab, are easily seen (Plate II., fig. 5). The free edges curve outwards from the base of the foot (Plate II., figs. 3 and 4), and, keeping a little inside of and parallel with the mantle edge, extend to a point just ventral to the exhalent orifice, where they narrow to a well-defined combined tip (fig. 3).

Of these four gills, two belong to each side of the body (*Br.*, Plate V., fig. 3), and each such lateral pair (Plate VIII., fig. 6) constitutes morphologically one ctenidium —so that one fold or "gill" is a hemi-ctenidium. The ctenidium consists of a vascular basis or axis upon which are inserted at right angles along its whole length two rows of long delicate branchial filaments, hollow outgrowths of the axis. As the axis extends from the ventral border of the palps anteriorly along the front edge of the visceral mass, nephridium and adductor muscle, and curves round ventrally and posteriorly to a point opposite the anus, with its convexity first forwards and then

downwards, it follows that these branchial filaments must be directed in the upper or oral region forwards, and in the lower or ventral downwards—in all cases towards the nearest margin of the valve.

The outwardly directed parallel filaments of each series are folded upon themselves, so that they become deeply V-shaped. The folding in each case is away from the common centre or axis, the external filament turning outwards and the internal inwards. Consequently, each branchial plate, formed of the doubled filaments, consists of two lamellæ—the direct and the reflected—which enclose between them a narrow inter-lamellar space (see Plate V., fig. 4)—where the outer lamella of the external hemi-ctenidium is the reflected, and the inner (that which is attached to the vascular axis) is the direct—the converse being the case with the internal hemi-ctenidium where the outer lamella is the direct one: the two direct lamellæ face one another.

Immediately behind the visceral mass the edges of the reflected lamellæ of the inner gills (*a.g.f.*, Plate VIII., fig. 7) of the two sides join loosely in the middle line, so as to show in a transverse section the form of two capital W's, imperfectly joined, thus—WW (Plate V., fig. 9, *Br.*). The free outer edge also adheres somewhat, under normal conditions, to the adjacent mantle by a thickened rim; but both the median and the lateral concrescing surfaces are readily separated with a little pressure, and it can scarcely be said that there is permanent fusion.

Histological examination of these places shows that the union is by means of very long and perfect ciliary junctions (Plate VIII., figs. 8, 9, 10), closely resembling in the appearance both of cells and cilia the ciliated discs of the filaments. At the extreme ventral edge of the median junction of the inner gills there is a very narrow but quite definite organic connection (Plate VIII., fig. 9, *org.*) which must be ruptured when the gills are pressed apart. At these ciliated junctions the epithelial cells are cubical or low columnar, with a distinct seam or margin from which the very regular stiff cilia project (figs. 9 and 10).

The common base (*ct.a.*, Plate VIII., fig. 6) of each ctenidium is a vascular attached ridge reaching from the anterior end of the gills, overlapped slightly by the bases of the palps, to a point near the anterior end of the adductor, thence running as a free axis to the posterior or distal extremity. It is seen in both conditions in sections on Plate V., attached in fig. 4 and free in fig. 9. Within the axis lie two great blood-vessels, the afferent and the efferent branchials. The former (*Br.aff.*, Plate VIII., fig. 8), which conducts the blood from the venous sinuses to the gills for purification, lies internal and dorsal to the latter (in Plate VIII., fig. 8, it appears as a tube above the efferent vessel, *Br.eff.*).

Hollow outgrowths, the inter-lamellar junctions, containing branches from the afferent vessels, convey blood from the axial trunk to the base of the reflected lamella. Thence the blood enters certain of the individual filaments, flowing outwards to the free margin, where it passes over into the direct filaments and so

returns inwards to the branchial axis, where it joins the efferent vessel by openings along each side. The branchial afferent vessels and the band-shaped inter-lamellar junctions (Plate VIII., figs. 8 and 12) are comparatively few, and each serves a group of 10 or 12 of the reflected filaments. On the other hand, each direct filament has its own aperture into the efferent vessel.

The filaments composing a lamella are not placed in one plane. On the contrary, the lamella is pleated or plicated regularly at right angles to its base, so as to have alternating shallow channels and rounded ridges (Plate VIII., fig. 12). The number of filaments constituting a plica varies from 10 to 12. The transverse section of the gills given in fig. 12 on Plate VIII. shows how the ridges are formed by the plication of the filaments. At the bottom of each channel there is a specially large and modified filament (Plate VIII., figs. 12 and 13, *p.f.*) with a great development of skeletal chitin and some muscle bundles. These are known as the principal filaments, and they have the inter-lamellar junctions attached to them and alone receive afferent branchial vessels. The aërated blood passes from the gills by the ordinary filaments.

Neighbouring filaments are joined by continuous organic union mainly at the lower and the upper ends of the reflected filaments, where there are longitudinally-running blood vessels. Elsewhere the filaments are joined chiefly by the interlocking stiff cilia of the large ciliated discs which occur at intervals (Plate VIII., fig. 11, *c.d.*) throughout their length. In many places, however, groups of two or three or more filaments (see figs. 16, 17) are united by true organic junctions which occur alongside the ciliated discs, as RIDEWOOD* suggested might possibly be the case. Fig. 16 shows four filaments united, I have found several examples of six, and in one specimen the whole twelve filaments of a plica were joined by continuous tissue. The concrescence is not always at the internal edge of the filaments, but may be about the middle, and in one case I found two unions between two neighbouring filaments leaving an ovate ciliated gap. But all such examples of true organic union are comparatively few and exceptional, and we certainly do not have in this gill the continuous solid inter-filamentar junctions which are found in the less simple gills of the Eulamellibranchiata (such as *Venus*, *Cardium*, *Mya* and *Anodonta*).

The frequency and arrangement of the ciliated discs is seen in fig. 11, representing a longitudinal section along several adjacent filaments, and a transverse section at the level of these junctions is seen in fig. 16. The epithelial cells bearing these special stiff cilia project beyond the general surface, and are of cubical or low columnar form.

The gill of the pearl oyster is thus what PELSENEER termed "Pseudolamellibranch," the lamellæ being plicated and connected by inter-lamellar vascular junctions, while the individual filaments are mainly united by the interlocking of the ciliated discs.

In transverse section the filament has a bluntly wedge-shaped outline, the narrower end being internal. The structure of an ordinary filament, where free from junctions,

* 'Phil. Trans.,' vol. 195, B, p. 155.

and more highly magnified, is shown in fig. 14. The epithelium on the surface is ectoderm, and this varies in height in certain parts, and is ciliated along special tracts, the chief of which are the frontal and the lateral (Plate VIII., figs. 13, 14). Underneath the epithelium of the gill filament is a thin layer of connective-tissue strengthened by chitinous thickenings. These skeletal thickenings take on a special development in the principal filament lying in the angle between two ridges (Plate VIII., fig. 13). Connective-tissue septa do not occur in the interior of the ordinary filaments, but at the level of the ciliated junctions the modified filaments which bear the discs may have their lumen largely obliterated by an unusual development of connective-tissue (fig. 15). Further details can be seen in the figures.

Apart from the special action of modified cilia in forming an interlocking junction, the normal function of the ordinary cilia on the branchiæ is to create the all-important current of water which enters the pallial chamber and passes over and through the branchial lamellæ, so as (1) to aërate the blood flowing in the filaments, and (2) to convey food particles to the mouth. The respiratory current is apparently due to the normal rhythmic lashing of the cilia on the large cells at the edges of the filaments; while the collection or rejection of particles in the water seems to be the result ot special action stimulated apparently by the irritation. Particles arrested by the branchial filter are caught up by the nearest cilia, which by local reversed lashing carry them outwards to the free ventral edge of the lamella. Here they are guided by the cilia of a pathway running along the branchial margin and are propelled forwards and upwards to the anterior end of the gill, where they come under the influence of the palps, to be accepted as food or rejected and conveyed to the exterior by the pallial ciliated band. On Plate VI., fig. 13 shows the ciliated paths, upon and between the gills, by which particles can approach the palpal gutters (*b.*) leading to the mouth (*a.*); and fig. 14 shows the track (*Pall.cil.b.*) along the mantle edge by which excreta pass to the exterior at the pallial fold (*Pall.f.*).

THE VASCULAR SYSTEM.

In common with all typical Lamellibranchs, *Margaritifera vulgaris* has a circulatory system consisting of a heart and a series of arteries, whence by means of irregular ill-defined spaces, the lacunæ, between and among the tissues and organs the blood flows into larger and usually well-defined thin-walled cavities, the venous sinuses. The bulk of the blood then circulates through the gills prior to being returned to the heart, but a portion passes direct from certain sinuses in the mantle. Of these vessels the arteries alone have definitely cellular walls, those of the sinuses being of connective-tissue.

The heart is contained in a thin-walled transparent sac, the pericardium (*Per.*, Plate VII., fig. 2), occupying nearly all of the posterior region of the body, the space bounded in front by the posterior limit of the viscero-pedal mass and behind by the

upper part of the adductor. While in front the pericardium is in contact wholly with the viscero-pedal mass, its floor is formed of the wide median communication between the right and left nephridia; posteriorly the pericardial wall is entirely free and coincident with the body-wall and forms the anterior and dorsal boundary of the adductor embayment of the supra-branchial chamber, and laterally its walls are also partially free.

Dorsally the walls gradually approach, and close to the apex are perforated by the rectum; so narrowed, however, is the portion of the pericardium above the latter that it appears in sagittal sections rather as a tubular connection uniting the lateral portions of the main pericardial chamber—the supra-rectal pericardial arch (*Per.ar.*, Plate VII., fig. 1). This part of the wall is separated from the dorsal or hinge portion of the body-wall only by some loose connective-tissue.

Anteriorly there arises on either side from each ventral corner a wide sleeve-shaped prolongation directed forwards, so that the two appear to clasp the viscero-pedal mass. These are the two reno-pericardial canals (*Rn.per.*, Plate VII., fig. 1) each of which opens anteriorly by a horizontal slit (*Rn.per.'*, Plate VII., fig. 8) into one of the nephridia close to the external renal orifice.

The heart largely fills the pericardial space and is clearly distinguished through the thin pericardial wall. It consists of a dorsally situated median ventricle (*v.*, figs. 1 and 2) and two lateral auricles (*au.*, fig. 1)—dark-walled and symmetric—lying ventral to the ventricle. The auricles are liver-coloured bodies with puckered walls, roughly triangular in form when viewed from behind. The apex of each is attached separately to its respective corner of the base of the ventricle. The two are connected medially by the junction of their inner corners, while thin sheets or partitions of connective-tissue anchor their bases to the floor of the pericardium immediately over the inter-nephridial passage. The walls are largely thickened by the presence of numerous accessory excretory glands—the pericardial glands—to which is due also their distinctive dark-brown hue (see p. 65 below for details of these glands).

An efferent blood-vessel from the gills enters each auricle at the outer angle of the base. The auricular cavities inter-communicate through the basal junction and are reduced in capacity by inward projections of the walls.

The lips of the auriculo-ventricular apertures project inwards and form simple yet effective valves preventing the reflux of blood into the auricles during the ventricular systole. The ventricle is elongated, of a pale yellowish-white tint; the walls are thick and muscular, and the cavity is further reduced by numerous muscular trabeculæ crossing in various directions. As Grobben first pointed out, this ventricle does not surround the rectum, as is so usual in Lamellibranchs, but its dorsal extremity is intimately fused with the lower surface of the rectum. The muscle fibres in the wall of the heart are distinctly striated (Plate IX., fig. 12).

Anteriorly and posteriorly the dorsal ends of the ventricle pass into the anterior and posterior aortæ respectively. The latter (*Ao.p.*, Plate VII., fig. 2), the smaller of

the two, passes backwards into the tissue surrounding the exposed part of the rectum and runs therein parallel with the latter to a point slightly above the anus (about $\frac{1}{8}$ inch in $2\frac{1}{2}$-year-old specimens). Here it changes its course, turning forwards into the hinder tendinous portion of the adductor muscle and immediately divides into two branches (Plate VII., figs. 4 and 5). One of these turns to the right, passing through the muscle parallel to and a little beneath its surface. Just before reaching the insertion of the muscle it turns abruptly at right angles and passes into the mantle—as the right posterior pallial artery (*Art.p.p.*, Plate VII., figs. 4 and 5). Its neighbour on the left—the left posterior pallial artery (*Art.p.p.'*)—passes under the rectum and into the tendinous part of the adductor, emerging and entering the left mantle lobe in a similar manner to the right branch.

Each of these arteries after entering the mantle runs forward along its junction with the adductor till opposite the paired pallial sense organ (*S.o.*, Plate VII., fig. 5). Curving forwards each then runs out to the inwardly projecting tongue of the mantle edge opposite the posterior gill tips. Here an anterior and a posterior branch are given off which run forwards and backwards respectively within the thickened pallial margin, parallel to and just beneath the pallial gutter.

The anterior branch meets a similar branch from the anterior pallial artery, the two so fused being the common pallial artery (Plate VI., fig. 2, *Art.c.p.*).

The anterior aorta (*Ao.A.*, Plate VI., fig. 2) passes forwards from the heart, above and to the left of the rectum, and then bends to the right and runs above and to the right of the stomach and œsophagus.

Of the many branches given off by this arterial trunk, by far the most important and largest is the first, the unpaired visceral artery (*Art.vis.*, Plate VI., fig. 2). This branches off immediately after the dorsal aorta crosses the rectum. It is rather wider than the continuation of the aorta. Turning ventrally, it penetrates the central portion of the viscero-pedal mass, crossing in its course to the left of the descending intestine and then giving off branches into the gonad and to the intestines.

Returning to the dorsal aorta, we find it supplying numerous arteries to right and left—and downwards—the chief of these being the hepato-pedal artery (*Art.h.p.*, Plate VI, fig. 2), given off just above the junction of the œsophagus with the stomach. Then branches are given off to the right and left labial palps, and beyond the mouth the aorta ends in two diverging branches—the right and left anterior pallial arteries (*Art.a.p.*), which pass ventrally within the mantle edge to fuse with the posterior pallial arteries as the common pallial artery (*Art.c.p.*).

The hepato-pedal artery, like the visceral, passes downwards to supply the viscero-pedal mass. Level with the floor of the stomach it bifurcates, the anterior branch going forwards to the foot as the pedal artery, the posterior branch—the hepatic artery—turning back to traverse the digestive gland. From the pedal a branch goes forwards and bifurcates to form twigs going right and left to the palps.

The blood stream, carried by the ultimate ramifications of the arteries, passes into

the lacunæ—irregular spaces between the tissues—whence it drains into larger cavities, the venous sinuses, which conduct directly to the heart (from the mantle) or indirectly by the intermediation of the gills.

The blood is colourless, and contains nucleated corpuscles, which are shown in some of the figures of the blood spaces in the gills (Plate VIII., figs. 11, 13).

THE EXCRETORY SYSTEM.

The renal excretory system consists of the paired nephridia and possibly of the numerous small pericardial glands projecting from the walls of the auricles. The nephridia consist of two large symmetrical pouch-like sacs lying one on either side of the hinder half of the viscero-pedal mass. Each opens into the pericardium by a wide duct and to the exterior by a minute pore, and they intercommunicate by a wide channel beneath the auricles. In outline each is roughly triangular, the apex passing into the channel under the auricles, while the elongated base looks outwards and forwards, coinciding with the base of the anterior third of the gill of that side, and thus conforming to the inclination of the gill.

The outer wall of the nephridium (*Neph.*, Plate VII., fig. 8) is thin and membranous; it is fused with the body-wall, as is also the most anterior portion of the inner wall, namely, that strip extending from the base of the gill to the viscero-pedal mass; from this line it runs back, overlying and in contact with the hinder part of the gonad, gradually narrowing as it approaches the auricle.

The external renal aperture (*Rn.o.*, Plate VII., fig. 8) is a minute oval opening furnished with a sphincter muscle. It opens immediately below the genital aperture, within an inconspicuous lipped slit, the urino-genital vestibule (Plate VII., figs. 10 and 12), placed at the junction of the inner plate of the inner gill with the visceral mass, at a point about mid-way between the ventral border of the latter and the base of the foot.

Each nephridium consists of a glandular and of a non-glandular portion. By separating the right and left ctenidia and reflecting each, the glandular region (*Neph.'*, Plate V., fig. 4) is seen as a narrow, elongated, coloured strip—yellow, or pale brown, or even dark dull red—bordering the anterior part of the inner base of each gill. It consists of spongy tissue, occupying the anterior angle formed by the meeting of the inner and outer walls of the organ, and the secretion passes from the cavernous chambers of the glandular region directly into the spacious cavity of the main or non-glandular portion. The spongy renal tissue shows, when magnified, branching tubes and septa formed of irregularly cubical cells much vacuolated and with very distinct nuclei (Plate IX., fig. 15).

The passage (*Np.con.*, Plate VII., fig. 8) connecting the right and left nephridia lies beneath the auricles. It is a wide tunnel with thin membranous walls, bounded behind by the lower part of the pericardium, while in front its wall lies against the

visceral mass, and below it fuses with the body-wall and so forms part of the roof of the adductor embayment of the supra-branchial chamber.

The reno-pericardial tubes (*Rn.per.*, Plate VII., fig. 8) are a pair of wide lateral prolongations of the pre-cardiac part of the pericardium, thin-walled and membranous, and directed forwards. Each gradually narrows towards the anterior end, where it opens into the non-glandular part of the nephridium of its own side. The aperture is a curved slit, with the concavity facing towards the ventral aspect (*Rn.per.'*). It has but one lip, the tube opening at a very acute angle. It is situated upon the inner wall of the nephridium, immediately to the rear of the external renal aperture. Usually, but not invariably, a small area around is rendered conspicuous by flecks of brown pigment.

Compared with the total bulk of the body, the size of the nephridial system is small, especially when we bear in mind the comparatively great size of this organ in some other Lamellibranchs, such as *Anodonta* and *Cardium*. There are, however, also the accessory pericardial glands, described by GROBBEN,* possessing an excretory function, situated on the walls of the auricles and on the neighbouring part of the pericardial wall; and it is the dark-brown colouring of these glands which renders the auricles most conspicuous objects in the dissection of the pearl oyster (see Plate VI., fig. 1). These glandular outgrowths increase largely the secretory area, as the auricular walls are thrown into numerous pouches, which are of a spongy structure, with deep folds of the inner surface dipping down into the blood stream. The epithelium shows large cubical, rounded or ovate cells packed with concretions and granules (Plate IX., fig. 13). The lower or auricular end of the pericardium is also glandular, and has its epithelium thrown into folds formed of granular vacuolated cells (Plate IX., fig. 14) of the same character as those of the nephridium. The secretion from all these pericardial glands passes by the wide reno-pericardial ducts into the nephridia, and thence gains the exterior by the renal aperture.

THE NERVOUS SYSTEM AND SENSE ORGANS.

The nervous system of the pearl oyster is of the ordinary Lamellibranch character, and is very similar to that of *Mytilus edulis*, the common mussel. The bi-laterally symmetrical central nervous system has 3 pairs of ganglia: (1) the cerebral ganglia at the sides of the œsophagus (Plate VI., fig. 15, *Cer.g.*), (2) the pedals conjoined to form a single ganglion (fig. 16, *Ped.g.*) at the base of the foot, and (3) a pair of large visceral or parieto-splanchnic ganglia (fig. 15, *Par.sp.g.*) lying upon the anterior surface of the adductor. These are connected as follows:—

Stout paired nerves, the cerebro-visceral connectives (*C.v.con.*), link the cerebral with the parieto-splanchnic ganglia (fig. 15), while a pair of similar cords—cerebro-pedal connectives (*C.p.con.*)—joins the cerebral with the pedal nerve mass (fig. 16).

* 'Arbeit. Zool. Instit. Wien,' Bd. VII., 1888.

The cerebral ganglia are pre-oral or supra-œsophageal in position, and a nerve cord or commissure, passing over the œsophagus, connects the two cerebral ganglia; while a single stout transverse cord—the visceral commissure—joins the two parieto-splanchnic ganglia (fig. 18).

The cerebro-visceral connectives surpass all the other commissural nerves in length. Taking their rise at the posterior end of the cerebral ganglion, each passes backwards and downwards, buried within the visceral mass, till it emerges opposite the upper angle of the base of the foot. Then it passes ventrally, overlaid by the renal sinus, whose course it follows till, entering the tissue at the base ot the gills, it turns slightly forwards—still passing ventrally—and ends in its respective parieto-splanchnic ganglion (fig. 15).

In addition to the supra-œsophageal cerebral commissures and to the connectives passing to the pedal and parieto-splanchnic ganglia respectively, the cerebral ganglion of each side gives off anteriorly a stout nerve—the anterior common pallial. This passes forwards, bifurcating almost immediately. The outer branch (the external pallial nerve) courses along the pallial edge, meeting and anastomosing with the corresponding external pallial branch of the posterior common pallial trunk. The labial palps and the otocysts are also innervated from the cerebral ganglia.

The cerebro-pedal connectives arise from the posterior and outer sides of the cerebral ganglia, and run downwards within the visceral mass and just behind the levator muscles of the foot to the pedal ganglion. They lie close together in their course, and about midway each gives off a nerve, passing posteriorly into the visceral mass.

The double nature of the pedal mass is distinctly seen in sections (Plate IX., figs. 16 and 16A). Three principal nerves arise from the pedal ganglion to innervate the foot and byssal gland (Plate VI., fig. 16). One, the dorsal (or superior) pedal nerve, given off from the upper anterior part, passes along the dorsal region of the foot to the tip of this organ, throwing off twigs as it goes. Its terminal portion innervates the locomotor or crawling portion of the foot. The second, the ventral (or inferior) pedal nerve, arises immediately below the last described, passes forwards and downwards and supplies the byssal groove and disc-pit. The byssal nerve is the third offshoot from the pedal ganglion; it comes away from the ventral end and passes direct to the byssal gland, dividing into numerous branches.

Each of the visceral or parieto-splanchnic ganglia receives from above the stout cerebro-visceral connective, the two ganglia being themselves united by a single transverse visceral commissure. In addition to these connecting nerves, each ganglion gives off two stout distributory nerves (Plate VI., fig. 18)—an anterior lateral (the branchial, *n.br.*) and a posterior (the pallial, *n.pal.*). Each branchial nerve leaves the ganglion at the anterior lateral corner, turns down at once into the base of the gills, and then passes backwards to the posterior tips following the course of the afferent vessel. The posterior common pallial nerves emerge from the posterior end

of the visceral ganglia; from the base of each a stout nerve (fig. 18, *n.s.o.*) passes straight back, parallel with its neighbour and midway between the median line and the margin of the adductor, till it reaches the pigmented pallial sense organ of its respective side—a little anterior to the anus.

After giving off the last-named nerves, the common pallial trunk passes backwards and outwards, bifurcating almost immediately; the external branch, the larger, is the external pallial nerve and straightway bends outwards and passes into the mantle; the inner branch pursues a more median course, but in turn it soon divides. The outer of the resultant nerves becomes the median pallial nerve; the inner the internal pallial nerve, the latter being the weakest of these three pallial trunks. By the ramifying of these three nerves in the muscular and marginal regions of the mantle, and by their anastomoses with a corresponding series of inner, outer, and median branches given off by the anterior common pallial trunks from the cerebral ganglion, a complex network of nerves termed the pallial plexus is formed. A somewhat similar arrangement of the pallial arteries is found—the marginal pallial artery having, like these pallial nerves, a double origin.

In the case of the nerves, we find the external pallial, as indicated by the name, passes directly to the margin along which it runs, branching as it goes; the median takes a parallel but more internal course, and anastomoses freely with its fellow outside, while the third or inner branch passes forwards along the line of insertion of the pallial retractors, branches being given off which meet and anastomose with others from the median. On tracing these three nerves forwards we find that they join the corresponding series arising from the anterior common pallial trunk.

Sense-Organs.

Specialized sense-organs are few and of low type in the pearl oyster, the only structures that can come under this head being the otocysts, the osphradia, and the pallial or abdominal organs of Thiele. The latter are a pair of slightly asymmetrical laterally compressed tubercles lying upon the ventral surface of the adductor muscle, one on either side, a little anterior to the anus. In each the long axis lies transverse to the greater axis of the body. Dark pigment renders them conspicuous, and the one to the right is distinctly the larger. It is also situated slightly further back than its neighbour. In sections these sensory papillæ are seen to be covered with epithelium which contains specialized sense-cells. Plate IX., fig. 17A, shows the tip of one of these sensory papillæ. They are innervated by a special nerve from the visceral ganglion, possibly derived from the cerebral, close to the posterior pallial nerve (Plate VI., fig. 17, *n.s.o.*). The function of these organs is probably olfactory or of such a (?) tactile nature as to test the quality of the water passing over the gills, or to be stimulated by particles it contains.

The otocyst, at the pedal mass, has numerous otoconia, and is supplied from the

cerebral ganglion. The osphradium is an area bounded by a well-marked projection close to the parieto-splanchnic ganglion at the origin of the branchial nerve. It has a small ganglionic mass lying at its base (Plate IX., fig. 18), and its nerve is cerebral in origin.

There are probably sensory cells in the ciliated epithelium on the grooved and corrugated oral surfaces of the labial palps (Plate IX., fig. 11); but the sense of touch seems to be localized chiefly in the margin of the mantle, and more especially in the filiform and digitate processes of the velum. These latter are extremely sensitive to touch, and the longer processes of the anterior and of the ventral margin have compound digitate apices; it is upon these multiple terminations (Plate IX., figs. 19, 20) that the chief sensory epithelial cells are disposed. The long processes of the posterior part of the mantle edge are of a different form. They are cylindrical filiform organs beset on all sides with short spinulate branches towards the tip (Plate III., fig. 9). Those on the margin of the temporary exhalent aperture are notably developed, and in life sway and sinuously bend in snake-like motion unceasingly. In sections they show a delicate columnar epithelium which is no doubt sensory.

Little can be said definitely regarding the sense of sight, although we have some evidence of the function being performed to a certain extent. Thus from the observations described in Part I., it is clear that there is a marked sensibility to light and shadow—a sensibility which may be termed dermatoptic, as it resides in the surface layer of certain regions. When the tanks were well lighted during the day, the shadow of a hand passing over was frequently followed by the immediate closing of the oyster's valves, and conversely after dusk they showed a similar but more accentuated re-action when stimulated by a bright light. Especially is this the case when surprised during a promenade, when having slipped their byssal cables they crawl along in search of a new resting place. At such times, or when forming new byssal threads, they appear extremely sensitive; they cease operations immediately and remain passive, with valves closed, as long as the irritation is continued. This photoscopic or dermatoptic sensibility can be located only in the soft parts turned towards the light—the edges of the mantle and the surface of the foot, when the latter is protruded—and there we invariably find patches of more or less deeply pigmented epithelial cells.

THE REPRODUCTIVE ORGANS.

The sexes are separate in *Margaritifera vulgaris*, and, as is shown by the experiments detailed on p. 125 in Part I., remain the same from season to season, *i.e.*, each individual is permanently either male or female throughout life.

The gonads (*Go.*, Plate VI., fig. 1) are paired but asymmetrical. The pair together forms a thick envelope covering the stomach, liver and first two sections of the intestine, and thus constitutes the greater part of the outside of the proximal portion

of the viscero-pedal mass (Plate IX., fig. 1). Yet although the gonads envelop the viscera of this region, they do not hide the byssal gland, which, lying excentrically, comes in contact with the body-wall on the right ; and when the viscero-pedal mass is viewed from this aspect (Plate VI., fig. 2), the byssal gland is seen as a broad band reaching from the base of the foot backwards to the right retractor muscle. This band has the appearance of dividing the right gonad into a dorsal larger part and a ventral smaller (Plate VI., fig. 15), a division more apparent than real, as the two parts are continuous to the left of the byssal gland. No portion of the reproductive glands extends into the foot proper, or into the mantle as in the case of *Mytilus*.

When mature, the male and the female gonads are practically indistinguishable from one another to the naked eye. Both are usually pale creamy yellow in colour; the male, in some cases, rather paler than the female. The male, too, is rather less bulky than the female; this, however, is no guide to the sex, as the bulk will in that case approximate to that of a partially developed female.

The gonads, testes or ovaries as the case may be, consist of branched tubuli, whereon cluster myriads of saccate cæca, the alveoli (Plate IX., figs. 21, 22). In these arise, by proliferation from the germinal epithelium of the walls, spermatozoa or ova, according to the sex. The accumulated ripened products filling these alveoli and tubuli are then passed on into three trunks, which converge into a single main vessel just within the external genital aperture (Plate VII., fig. 11). This opens immediately dorsal to the renal aperture of the same side, and, indeed, the vestibule into which they both open is really a deep cleft whereof the V-shaped bottom merges imperceptibly into the primary genital duct.

The spermatozoa (Plate IX., fig. 22A) are excessively minute and of the typical form. The head is comparatively large, clear, and highly refractile, ovate in outline; while the long flagellum, proceeding from its more rounded end, is from nine to twelve times the length of the head.

The ovarian ova (Plate IX., fig. 21), measuring 16 μ by 8 μ, are more or less polygonal in form, by reason of mutual pressure, while within the alveoli and tubuli of the female gonad ; but when shed they become of a laterally compressed pyriform, or ovate, shape. The former is most characteristic—the narrow short stalk marking what was originally the place of attachment to the germinal epithelium. When fertilization takes place, the stalk functions as a micropyle. The vitelline membrane enclosing the coarsely-granular vitellus is thin. The nucleus is large, oval in outline, very clear, and but lightly granular, in length and in breadth exceeding the half length and the half breadth of the entire ovum. A nucleolus is also present, very conspicuously situated within the nucleus, close to its periphery. The more detailed characters of the ovum and the fertilization and early embryology will be discussed in a future Part of the Report in connection with the Life-History of the Pearl Oyster.

EXPLANATION OF PLATES.

List of Reference Letters.

Add., adductor muscle.
Add.', peripheral portion of *Add.*
Add.'', central portion.
Add.''', adductor impression.
An. or *a.*, anus.
An.f., anal funnel.
Ao.a., anterior aorta.
Ao.p., posterior aorta.
Art.a.p., anterior pallial artery.
Art.c.p., common pallial artery.
Art.h.p., hepato-pedal artery.
Art.p.p., right posterior pallial artery.
Art.p.p.', left " "
Art.vis., visceral artery.
Au., auricles.
B.c., blood corpuscles.
Br., branchiæ.
Br.aff., common afferent branchial vessel.
Br.eff., " efferent "
Br.int., internal branchia.
By., byssus.
By.d.p., byssus disc-pit.
By.p., byssal pouch.
By.p.', pleated surface of byssal gland.
By.p.gl., glands forming byssus.
By.r., root of byssus.
By.s., byssal sinus.
By.t., byssal tube, or groove.
C.c., granular cells with concretions.
C.d., ciliated disc.
Cer.g., cerebral ganglion.
C.p.con., cerebro-pedal connective.
Ct., ctenidium.
Ct.a., ctenidial axis.
C.v.con., cerebro-visceral connective.
D.a.l., antero-lateral hepatic duct.
D.gl., digestive gland.
D.p.i., pre-intestinal duct.
D.p.l., postero-lateral duct.
D.p.v., postero-ventral duct.
D.s.c., sub-central duct.
D.s.œ., sub-œsophageal duct.
Exc.o., excurrent orifice.
F., foot.
F.by.p., folds of byssal gland.
Fib.ret., fibres of retractor muscle.
G.f., gill filament.
Go., gonad.
Go.', external aperture of gonad.
I.l.j., inter-lamellar junction.
Int.ap., intestinal aperture in stomach.
Int.lp., intestinal loop.
Int. 1, descending intestine.
Int. 2, ascending "
Int. 3, rectum.
Lev.a., anterior levator muscles.
Lev.p., posterior "
Lig., ligament.
M.b., muscle bundle.
Mg.pall., pallial margin.
Mg.vel., edge of velum.
My., muscular tissue.
N., or *n.*, nerve.
N.br., branchial nerve.
Neph., sac of nephridium.
Neph.', glandular portion of nephridium.
N.pal., pallial nerves.
Np.con., channel between nephridia.
N.s.o., nerve to pallial sense organ.
O., mouth.
Oe., œsophagus.
Org., organic connection in branchiæ.
Os., osphradium.
Pa., labial palps.
Pa.d., dorsal palp.
Pall.', centre of pallial lobe.
Pall.'', muscular region of mantle.
Pall.cil.b., pallial ciliary band.
Pall.f., pallial fold (opposite tips of branchiæ).
Par.sp.g., parieto-splanchnic ganglia.
Pa.v., ventral palp.
Ped.g., pedal ganglion.
Ped.loc., locomotor part of foot.
Per., pericardium.
Per.ar., supra-rectal pericardial arch.
Per.ostr., periostracum of shell.
P.f., principal filament in gills.
P.i.dep., pre-intestinal depression.
Pl.d., dendritic plate of stomach.
Pr.dig., digitate process of valve.

Pris., prismatic layer of shell.
P.v.f., postero-ventral fold of stomach.
Ret., pedal retractor muscle.
Ret.', impression of retractor muscle.
Ret.ins., insertion of retractor muscle.
Ret.pall., pallial retractor muscle.
Rn.o., renal orifice.
Rn.per., reno-pericardial canal.
Rn.per.', aperture of last.
Rn.s., renal sinus.
R.r., rectal ridge.
Sn.add.lat., lateral adductor sinus.
Sn.m., median sinus.
Sn.tr., transverse sinus.
S.o., pallial sense organ.
S.œ.p., sub-œsophageal pit.
St., stomach.
St. 1, intestinal or pyloric chamber of stomach.
St. 2, right or cæcal chamber of stomach.
Ty., typhlosole.
V., ventricle.
Vel., velum of mantle.
Vel.pr., velar processes.
V.l., visceral lobe.
V.m., visceral mass.

PLATE I.

Fig. 1. Right valve of a specimen of the Ceylon pearl oyster (*Margaritifera vulgaris*) from Kondatchi Paar, showing an unusually smooth and rounded form; nat. size. This seems very similar to the "Shark's Bay shell," described by JAMESON as *M. carchariarum.*

„ 2. Right valve of another specimen of the same species brought up in the same haul from Kondatchi Paar, to illustrate variation in the shell; nat. size.

„ 3. Inside of right valve of an unusually wide specimen from Kondatchi Paar, showing a broad margin devoid of nacre and very large auricles; nat. size.

„ 4. Inside of left valve of a more normal shell, from Cheval Paar, showing well-developed nacre and a group of small pearls near the anterior auricle; nat. size.

„ 5. Outside of left valve of an unusually straight and narrow specimen, from Cheval Paar, the surface covered with Polyzoa and other organisms; nat. size.

„ 6. Outside of left valve of an unusually oblique specimen from Cheval Paar, the surface largely covered with adhering organisms; nat. size.

(Figs. 1 and 2 from drawings by Mr. J. HORNELL; figs. 3 to 6 from photographs by W. A. H.)

PLATE II.

Figs. 1 and 2 show photographs (W. A. H.) of the inside and outside of the valve of a normally developed pearl oyster, showing form, markings and nacre; slightly reduced.

Fig. 3. From a photograph (J. H.) of the animal after removal of the left valve, showing foot and byssus, mantle, gills, adductor muscle, &c.; nat. size.

„ 4. From a photograph (J. H.) of pearl oysters from (A) Muttuvaratu Paar and (B) East Cheval Paar, of the same age (3 years to 3½ years) to show the marked difference in growth; nat. size.

„ 5. From a photograph (J. H.) of three pearl oysters seen edgeways, to show adductor muscle and mantle lobes; nat. size.

„ 6. From a photograph (J. H.) of a pearl oyster with the right valve removed and dissected to show the adductor muscle, foot, &c.; nat. size.

PLATE III.

Figs. 1 to 5 show differences in the soft parts of three species of "pearl oysters."

Fig. 1. Anal funnel of *Margaritifera* sp. (?)—a small, flat, dark brown species, A in ventral and B in lateral view; enlarged; *a.*, anus.

„ 2. Ventral part of visceral mass of same species from the side; nat. size.

„ 3. Anal funnel of *M. vulgaris* (SCHUM.), A in ventral and B in lateral view; enlarged; *a.*, anus.

Fig. 4. Ventral part of visceral mass of same species, from the side, showing the visceral lobe (*v.l.*) more prominent and more distinctly separated than in fig. 2; nat. size.

,, 5. Palmate anal funnel of *M. margaritifera* (LINN.); enlarged.

,, 6. Marginal processes from ventral part of velum; *s.h.*, sensory tufts on tips of branches.

,, 7. Similar processes from another individual.

,, 8. Simpler processes of the pallial edge—typical forms.

,, 9. Some variations in the longer processes of the pallial edge; *a*, from near exhalent orifice; *b*, *c*, *d*, common forms; *e*, bifurcate form, unusual—all these processes × 4.

,, 10. Semi-diagrammatic view of posterior aspect of living pearl oyster, showing the usual circular appearance of exhalent orifice; enlarged; *My.pall.*, edge of mantle lobe; *Pall.f.*, pallial fold; *Vel.pr.*, velar processes interdigitating.

,, 11. An abnormal anal funnel, the tip being bifurcate (compare fig. 3, A); enlarged.

,, 12. An abnormal foot (from South-east Cheval), the tip being bifurcate. The lateral branch is non-functional, its groove having no connection with the byssal gutter and pit (compare fig. 18).

,, 13. Dissection showing foot (ventral surface) lying at rest within the mantle cavity; three byssal fibres are present; nat. size.

,, 14. Lateral view of the foot at rest; nat. size.

,, 15. Foot extended in the act of secreting a new byssal fibre; the locomotor region and the byssal disc-pit are pressed against the rock *a*; *By.p.*, byssus pore.

,, 16. Foot retracted from rock to reveal the new byssal fibre; *By.d.p.*, the disc-pit in which the attachment disc of the fibre was moulded—the lips have partially closed.

,, 17. Diagram showing the relative positions of the parts during and after the secretion of a byssal fibre.

,, 18. Ventral surface of foot when, the old byssus having been cast off, the animal is crawling with tip of foot searching for a new place of attachment.

,, 19. The same as seen through a glass plate over which the animal is crawling by means of its flattened locomotor region; *By.p.*, byssus pore; *By.d.p.*, byssus disc-pit; *By.t.*, byssus groove; *Ped.loc.*, distal locomotor region.

,, 20. The same when attached by byssus, and elongated for the purpose of forming a fourth byssal fibre (compare with fig. 15).

,, 21. Semi-diagrammatic transverse sections through foot; *a* and *b*, through the distal locomotor region; *c* and *d*, through the proximal secretory region; *x*, locomotor surface; *By.t.*, byssal groove; the shaded part is secretory, the unshaded part mainly muscular (compare figs. 3 and 4 on Plate VIII.). All these figures of foot are about natural size.

,, 22. Sagittal section through foot and byssal organ; *By.*, byssus; *By.p.'*, pleated surface of byssal gland; *By.p.gl.*, glandular tissue of byssal gland; *By.t.*, byssal groove; *My.*, muscular tissue of foot; *Ped.loc.*, locomotor distal third of foot.

,, 23. The byssus: A, an entire byssus which was sloughed off by the oyster, showing the numerous fibres uniting in a common root lodged in the byssal pouch; B, one side of root of same byssus enlarged; C, reverse side of same root, showing furrows and ridges in dendritic form moulded in the pleated surface of the byssal gland—the two sides of the root diverge in some cases to form two separate masses of rootlets; D, distal end of byssal fibre, showing the disc of attachment, *a*.

,, 24. Antero-ventral view of visceral mass, looking towards pericardium to show relative positions of the retractor and adductor muscles; nat. size.

,, 25. Dissection from right side to show the course of the retractor muscle from its origin (*Ret.*) in the shell to its insertion (*Or.*) at the base of the foot. The visceral mass is shaded dark. The right mantle lobe is cut away along line *a*; nat. size.

,, 26. Dissection to show the course of the anterior (*Lev.a.*) and the posterior (*Lev.p.*) levator muscles, and the manner of their attachment to the base of the foot (F.).

PLATE IV.

Fig. 1. Outer surface of the mantle, as seen from left side on removal of valve, to show the number and arrangement of the insertions of the pallial muscles; nat. size. *Add.*, adductor muscle; *Ret.*, retractor muscle; *Lev.a.* and *Lev.p.*, anterior and posterior levators.

Figs. 2 to 6. Drawings of the interior of five pearl-oyster valves to show the variations in the arrangement and number of the scars produced by the insertion of the pallial muscles; nat. size. *Lev.a.* and *Lev.p.* indicate the scars of the anterior and posterior levators of the foot.

PLATE V.

Showing a series of sections across the body at different levels; slightly enlarged. D, dorsal; V, ventral; R, right, and L, left side of body.

Figs. 1 to 8. Vertical transverse sections in series from before backwards.

Fig. 1. Through œsophagus (*Oe.*); anterior end of byssal pouch (*By.p.*); palps (*Pa.*); anterior and posterior levator muscles (*Lev.a.*, *Lev.p.*); gonad (*Go.*); mantle lobe (*Pall.'*, *Pall.''*); pallial edge (*Mg.Pall.*); and velum (*Vel.*).

,, 2. Through anterior part of stomach (*St.*), parallel with last, showing also digestive gland (*D.gl.*) and hepato-pedal artery (*Art.h.p.*).

,, 3. Parallel with last, through lower part of byssal pouch with byssus-root (*By.r.*); antero-dorsal tip of nephridial sac (*Neph.*); end of intestinal loop (*Int.lp.*); and obliquely through branchiæ (*Br.*).

,, 4. A little posterior to last, showing postero-ventral hepatic duct opening into stomach (*St.*); glandular part of nephridium (*Neph.'*); sections through intestinal loop (*Int.lp.*); and anterior ends of the two retractors (*Ret.*) joining on posterior wall of byssal gland.

,, 5. Through posterior end of stomach (*St.*), showing intestine (*Int.* 1) leaving stomach, the two retractor muscles (*Ret.*) converging towards byssal pouch; nephridial sacs (*Neph.*) at their widest; Adductor muscle (*Add.'*), &c.

,, 6. In vertical plane immediately behind stomach, along ascending intestine (*Int.* 2), two portions of adductor (*Add.'* and *Add.''*); visceral artery (*Art. vis.*) descending through gonad, &c.

,, 7. Through the auricles (*Au.*) and posterior end of visceral mass with rectum (*Int.* 3); insertion of retractors (*Ret.*); pericardium (*Per.*); median venous sinus (*Sn.m.*); and lateral adductor sinuses (*Sn.add.lat.'*).

,, 8. Through ventricle (*V.*) and rectum (*Int.* 3), upper and posterior part of auricles (*Au.*), pericardial arch (*Per.ar.*), anterior aorta (*Ao.a.*), branches of median sinus (*Sn.m.'*), &c.

,, 9. Oblique dorso-ventral section through middle of visceral mass, adductor muscle, &c., as before.

Figs. 10 to 14. Horizontal sections at different levels, working downwards.

Fig. 10. At level of stomach (*St.*), showing anterior levators (*Lev.a.*) in transverse section, palps (*Pa.*), supra-cardial part of rectum (*Int.* 3), pericardial arch (*Per.ar.*), and an arrow entering anterior aorta cut obliquely.

,, 11. At level of ventricle (*V.*) and dorsal part of foot (*F.*), showing 3 sections of the intestine (*Int.* 1, 2, 3), palps (*Pa.*), &c.

,, 12. At level of auricles (*Au.*), showing auriculo-ventricular apertures, rectal ridge (*R.r.*) on posterior face of adductor, &c.

,, 13. Through middle of foot, showing origin of retractors (*Ret.*), inter-auricular communication, &c.

,, 14 Through byssal gland and root of byssus (*By.r.*), showing course of retractor muscles to insertion (*Ret.ins.*), &c.

PLATE VI.

Fig. 1. General anatomy of the pearl oyster as seen in sagittal section. The alimentary canal is slightly diagrammatic, as the limbs of the visceral loop do not lie in one plane, and neither the descending nor the ascending parts of the intestine are exactly in the median plane, and consequently would not occur in the one section. The size is that of a $2\frac{1}{2}$-year-old oyster. For the explanation of the reference letters, see list on p. 70.

,, 2. Dissection (semi-diagrammatic in parts) in same position as last figure, to show the principal arteries, see explanation of reference letters on p. 70.

,, 3. Dissection of the alimentary canal; nat. size.

,, 4. Transverse vertical section through dorsal part of visceral mass, passing through posterior part of stomach to show the two parts separated by the postero-ventral fold (*P.v.f.*) and the intestinal aperature (*Int.ap.*); enlarged.

,, 5. Horizontal section through visceral mass at base of the byssal gland, showing the retractor muscle fibres (*Fib.ret.*) inserted into the wall of the folded byssal gland (*F.by.p.*); *Go.*, gonad; *Art.*, arteries; *Int.* 1 and 2, descending and ascending parts of intestine; enlarged.

,, 6. Stomach bisected horizontally; roof viewed from below, to show the opening of the œsophagus (*œ.*) and ducts; enlarged. Stomach wall in solid black.

,, 7. Floor of same stomach viewed from above, to show dendritic plate (*Pl.d.*) and the various openings; enlarged.

,, 8. Diagrammatic longitudinal vertical section of the stomach to the right of the median line, to show ducts entering; enlarged.

,, 9. Diagrammatic longitudinal vertical section of the stomach to the left of the median line, to show ducts entering; enlarged.

,, 10. Outline of cavity of first or descending part of intestine: *a*, cæcum of crystalline style; *b*, intestinal cavity proper; enlarged.

,, 11. Portion of second or ascending part of intestine, opened to show the typhlosole (*Ty.*); enlarged.

,, 12. Transverse section through rectal ridge, on posterior surface of adductor muscle, to show rectum (*a*) with its typhlosole (*Ty.*); *c*, loose connective tissue; *b*, posterior aorta (see also Plate IX., figs. 6 and 7); enlarged.

,, 13. Diagram to show the ciliated paths leading from the gills by the palpar gutters (*b*) to the mouth (*a*); *d*, channel between base of external gill and mantle; *e*, at junction of external with internal gills; *f*, at junction of internal gills; *h*, along crest of external gill; *i*, along crest of internal gill. The paths diverge, converge, and join as shown.

,, 14. Dissection to show the course of the ciliated track (*Pall.cil.b.'*) from labial palp (*Pa.*) along base of velum to pallial fold (*Pall.f.*), opposite posterior tips of gills. *Ret.pall.*, pallial retractor muscles; *Pel.*, particles ejected; nat. size.

,, 15. Dissection from the right side, with right pallial lobe and right ctenidium removed, in order to show the course of the cerebro-visceral connective (*C.v.con.*); nat. size.

,, 16. Diagram of the pedal ganglion (*Ped.g.*) and its connections and nerves; nat. size.

,, 17. Posterior surface of adductor muscle (*Add.*), showing the parieto-splanchnic ganglia (*Par.sp.g.*) and their nerves; *n.br.*, branchial nerve; *n.pal.*, pallial nerves; *n.s.o.*, nerve to sense-organ (*S.o.*); nat. size.

,, 18. Ventral aspect of adductor muscle and visceral mass (*v.m.*), to show the nerves given off by the parieto-splanchnic ganglia; nat. size. Lettering as in last figure.

PLATE VII.

Fig. 1. Diagram of the heart and pericardium, seen from behind; enlarged.

,, 2. The same from right side. Lettering for both figures:—

Au., auricle; *V.*, ventricle; *Per.*, pericardium; *Rn.per.*, reno-pericardial canal; *Np.con.*,

channel connecting nephridia; *Per.ar.*, pericardial arch; *Int.* 3, rectum; *Ao.a.*, anterior aorta; *Ao.p.*, posterior aorta.

Fig. 3. Dissection of dorsal surface of visceral mass, seen from above, enlarged; to show branches of anterior aorta (*Ao.a.*).

,, 4. Semi-diagrammatic vertical section through rectal ridge and adductor muscle, to show posterior aorta (*Ao.p.*) branching into right and left posterior pallial arteries (*art.p.p.*); enlarged.

,, 5. Course of the posterior pallial arteries from their origin in the posterior aorta close to the anal funnel (*An.f.*) out to the pallial margin; nat. size.

,, 6. Plan of the venous sinuses on the ventral and posterior aspects of the adductor muscle; enlarged. For lettering see p. 70.

,, 7. Plan of the same from the dorsal aspect, enlarged; showing especially the main and branch branchial afferent vessels (*Br.aff.*) to the gills. *Rn.s.*, renal sinus.

,, 8. Diagrammatic representation of the nephridial system and its relations to the pericardium. The arrows show the reno-pericardial canal (*Rn.per.'*) and the external renal aperture (*Rn.o.*).

,, 9. Enlarged view of the external renal aperture (*Rn.o.*) and of the reno-pericardial opening (*Rn.per.'*).

,, 10. Opening of the urino-genital vestibule at the junction of base of ctenidium (*ct.*) with the wall of the visceral mass (*v.m.*); enlarged.

,, 11. Transverse section through the urino-genital opening, showing the emergence of the genital duct; enlarged.

,, 12. More enlarged view of the urino-genital opening; *a.*, genital aperture.

,, 13. Anastomosis of the muscle fibres of the pallial muscles. × 40.

,, 14. A thin process from the growing margin of the shell, to show the "cellular" structure of the conchiolin in which the calcareous matter is laid down. × 40.

,, 15. Margin of the shell showing the same structure. × 40.

,, 16. Some prisms from a thick section of the prismatic layer. × 50.

,, 17. Part of a section of the prismatic layer decalcified to show the conchiolin framework. × 100.

,, 18. Part of a section of the prismatic layer showing the ends of the prisms and the distribution of pigment, × 50. A. shows one prism more magnified containing granular pigment.

,, 19. A, B, C, stages in the decalcification of prisms, × 100; D, the conchiolin framework; E, part of conchiolin more highly magnified to show layers of deposition.

,, 20. The nacre in surface view showing contour lines, × 300; A, more enlarged.

,, 21. Another part showing the granular appearance sometimes seen. × 300.

,, 22. Decalcified nacre, looking like a very much crumpled and folded membrane. × 300.

PLATE VIII.

Fig. 1. Section through the margin of decalcified shell to show the successively formed layers of prismatic material separating at the free edge. × 50.

,, 2. Section of the mantle lobe showing the marginal and velar processes. × 50.

A, B, C, D and E show the character of the epithelium, &c., at the points indicated, more highly magnified. × 500.

,, 3. Transverse section of the foot in the distal locomotor part. × 50.

,, 4. ,, ,, ,, ,, region of the byssal groove. × 50.

,, 5. Transverse section of part of the byssus gland, showing the secretion lying in the lamellar ducts. × 50.

,, 6. Dissection of posterior part of left ctenidium (the outer and inner gills of the left side). × 2.

,, 7. Diagrammatic transverse section across the two ctenidia, to show the median ciliated junction (*M.c.j.*) between the two inner gills and the lateral ciliated junctions (*L.c.j.*) between the outer gills and the mantle lobe. × 2.

Fig. 8. Transverse section through the left mantle lobe and both ctenidia, to show their relations and the extent of the median (*M.c.j.*) and lateral (*L.c.j.*) ciliated junctions. × 15.

,, 9. The median ciliated junction between the inner lamellæ of the inner gills; *org.*, slight organic connection. × 400.

,, 10. The lateral ciliated junction between the outer lamella of the outer gill (*g.f.*) and the mantle lobe (*Pall.*) × 400.

,, 11. Longitudinal section along the gill filaments, to show the ciliated discs (*c.d.*). × 50.

,, 12. Horizontal section across the two ctenidia (four "gills," *o.g.* and *i.g.*), to show the plication, the interlamellar junctions (*i.l.j.*), and the principal filaments (*p.f.*). × 50.

,, 13. Small part of such a horizontal section more highly magnified, to show a principal filament (*p.f.*), several ordinary filaments (*g.f.*), and an interlamellar junction (*i.l.j.*). × 400.

,, 14. An ordinary gill filament in transverse section, to show cilia, &c. × 500.

,, 15. Transverse section of a filament at the level of a ciliated disc (*c.d.*). × 500.

,, 16. Section showing filaments joined by organic union at the level of the ciliated discs. *a* is an ordinary filament free; *b* is a filament with a ciliated junction; *c*, *d*, *e* show ciliated and organic junctions together; *f* shows a ciliated junction alone. × 400.

,, 17. Another group of two filaments showing organic union. × 400.

PLATE IX.

Fig. 1. Section through visceral mass, to show stomach (*St.*), cæca and ducts of digestive gland (*D.gl.*), gonad (*Go.*), &c. *P.* shows an encysted Cestode larva. × 20.

,, 2. Another section of the stomach and digestive gland more highly magnified. × 50.

,, 3. Duct of digestive gland terminating in cæca. × 50.

,, 4. Transverse section of cæcum of digestive gland. × 400.

,, 5. Transverse section of pallial muscle bundle enclosing branch of pallial nerve (*n.*). × 400.

,, 6. Transverse section of rectal ridge (*R.r.*), showing rectum (*Int.*3), posterior aorta (*Ao.p.*), and loose connective-tissue. × 50.

,, 7. Section across another part of rectal ridge further back. × 50.

,, 8. Part of transverse section of rectum more highly magnified, to show epithelium. × 400.

,, 9. Part of wall of stomach highly magnified, to show epithelium. × 400.

,, 10. Transverse section of intestine near the loop, to show irregular typhlosole. × 50.

,, 11. Section across labial palps. × 50.

,, 12. Part of wall of heart, to show striped muscle fibres of the ventricle. × 400.

,, 13. Part of wall of auricle, to show gland cells. × 400.

,, 14. Section through ventral end of pericardium, to show pericardial glands. × 50. A, a part more highly magnified. × 400.

,, 15. Section from glandular part of nephridium, to show renal cells. × 400.

,, 16. Transverse section of pedal ganglionic mass. × 50.

,, 16A. Another section showing junction of cerebro-pedal connectives. × 50.

,, 17. Pallial sense-organ. × 50. A, the apex more highly magnified. × 400.

,, 18. Section showing parieto-splanchnic ganglion and osphradium. × 50.

,, 19. Sensory papilla on pallial tentacle. × 500.

,, 20. Tip of velar papilla. × 500.

,, 21. Section through female gonad, to show developing ova. × 400.

,, 22. Section through male gonad, to show tubules filled with developing spermatozoa. × 100. A, part of a cæcum more highly magnified. × 400.

Fig. 1.

Fig. 2.

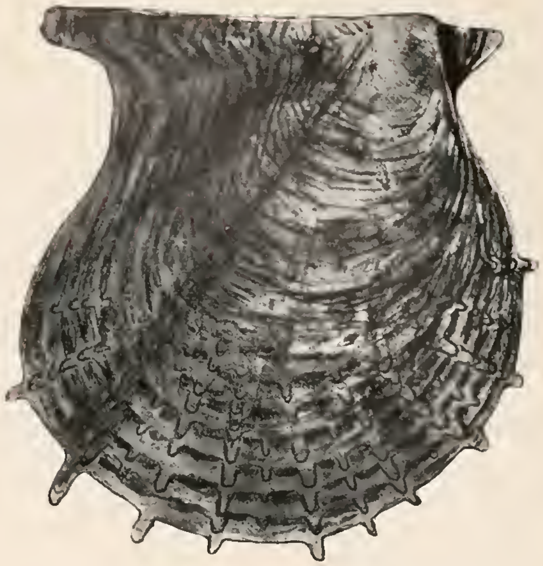
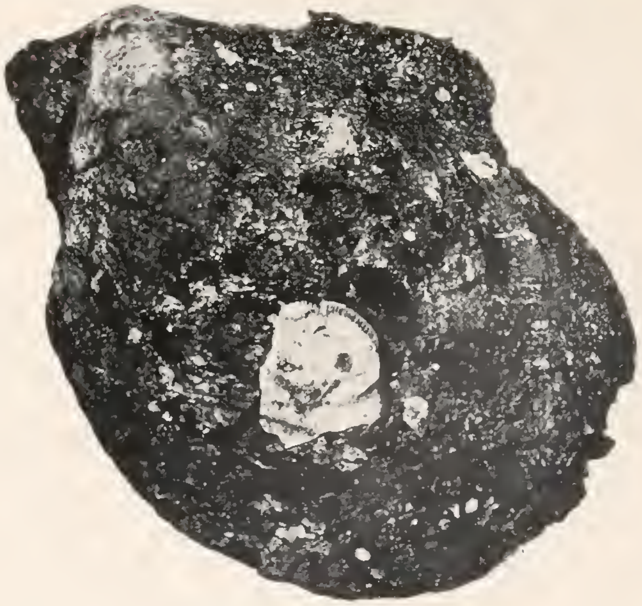


Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.



Variations in Shell Form.

Fig. 1.

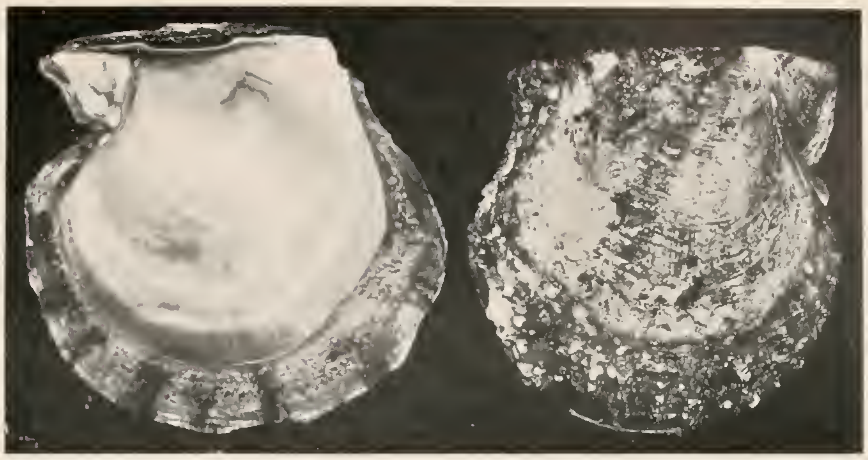


Fig. 2

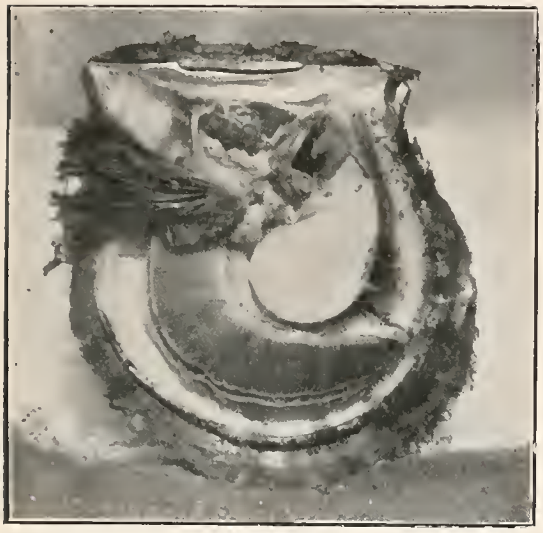


Fig. 3.

A. B.

Fig. 4.

A. B. C.

Fig. 5.

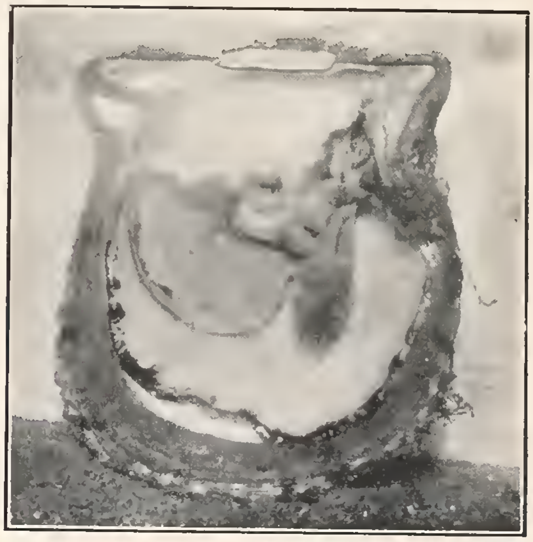


Fig. 6.

Shell and Animal.

MANTLE, FOOT AND BYSSUS.

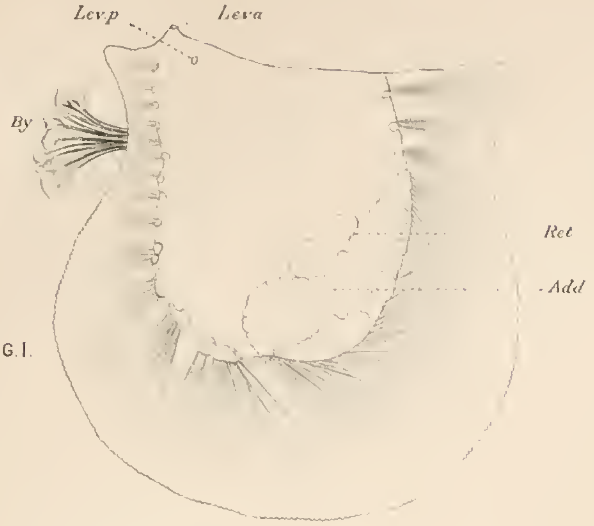


FIG. 1.

FIG. 2

FIG. 3.

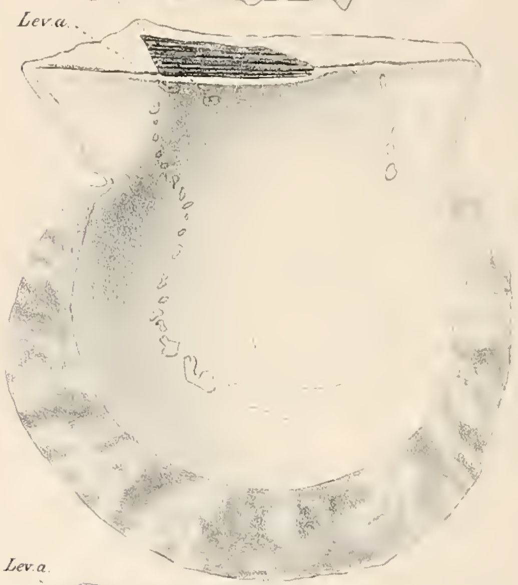


FIG. 4.

FIG 5.

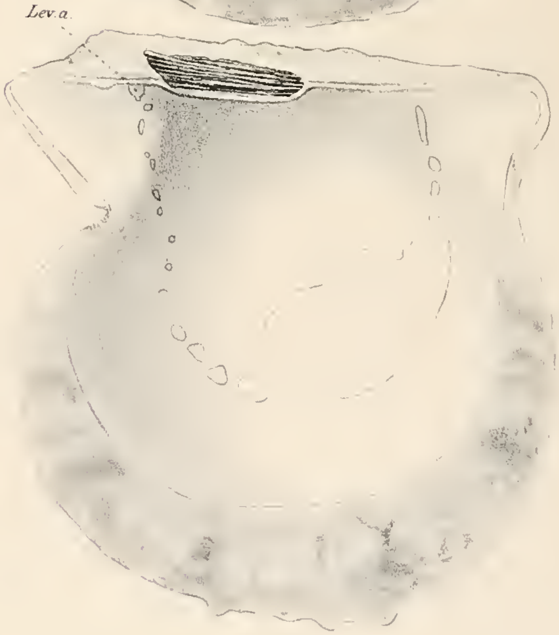


FIG. 6

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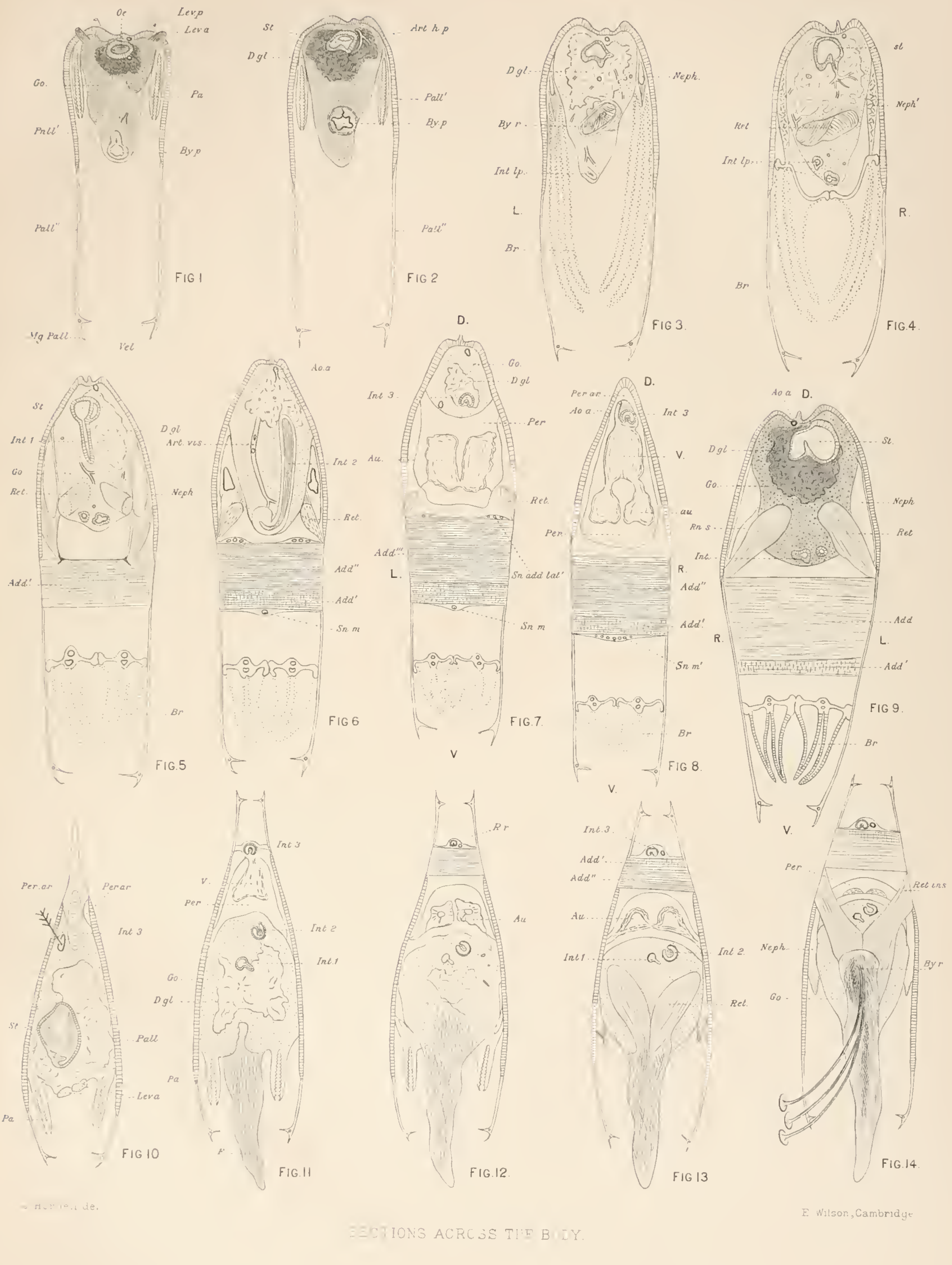
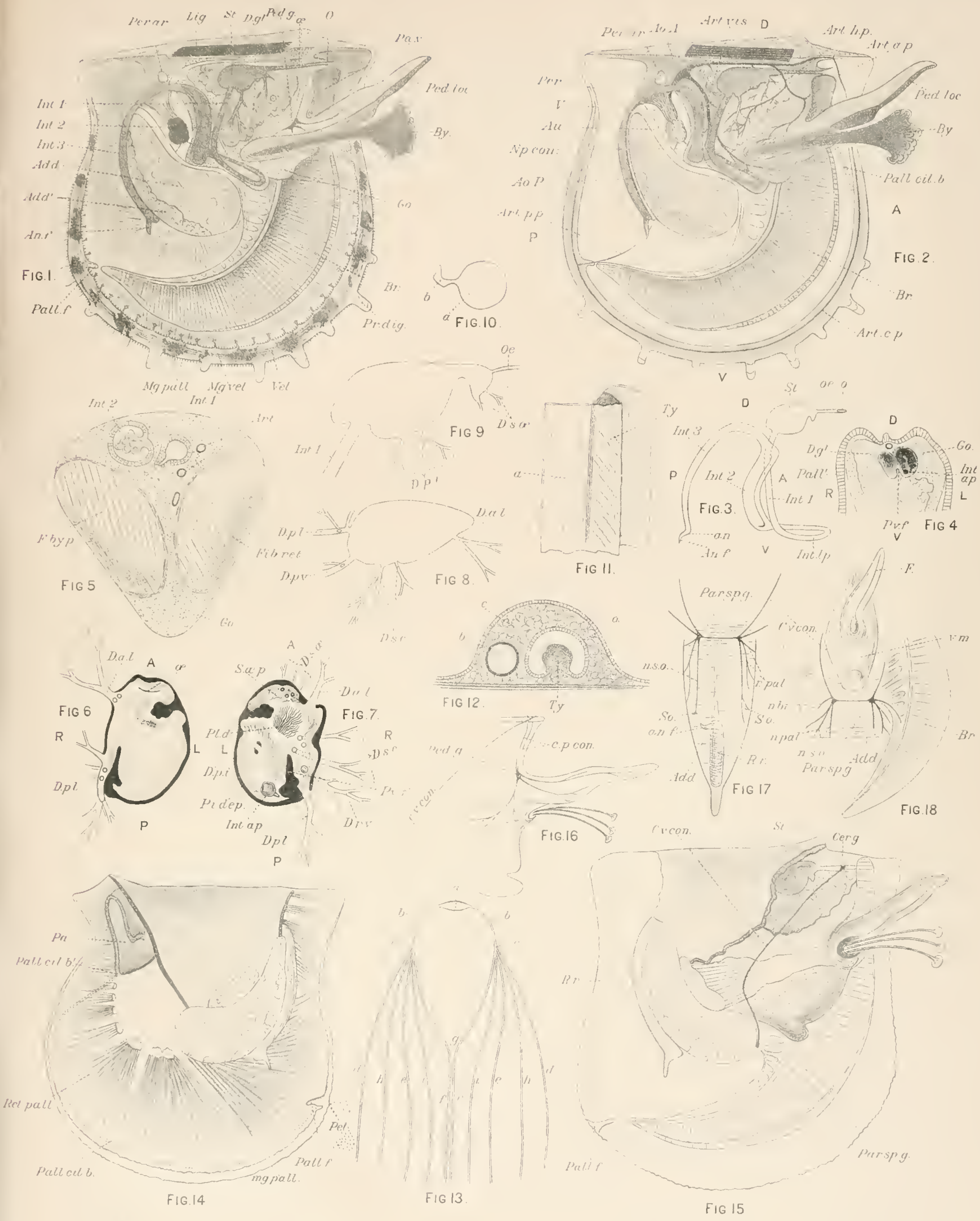
E. Wilson, Cambridge.

MUSCLE INSERTIONS



SECTIONS ACROSS THE BODY.

E Wilson, Cambridge



J. Hornell del.

E. Wilson, Cambridge.

ALIMENTARY CANAL, NERVES &c.

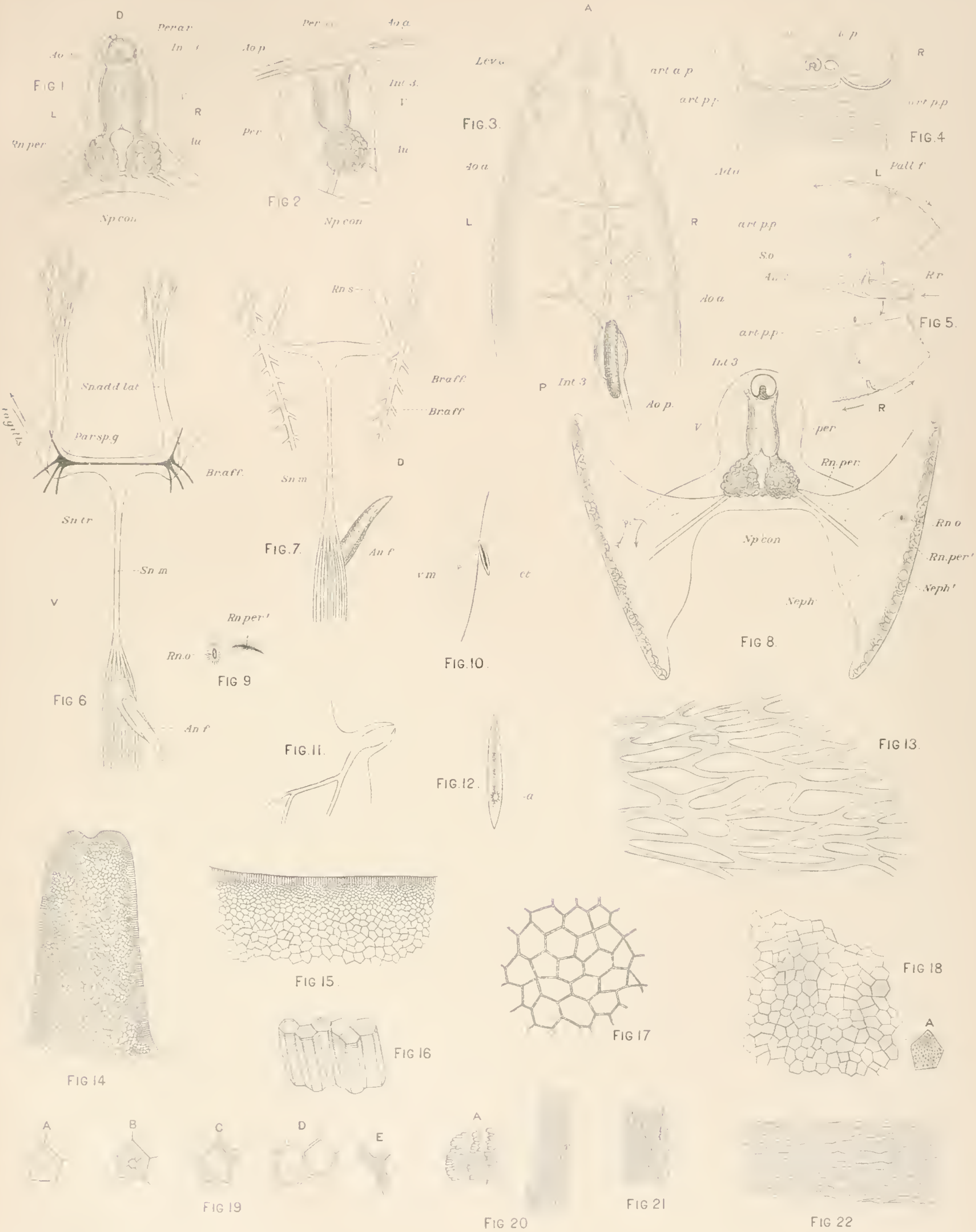

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Fig 20
Fig 21
Fig 22

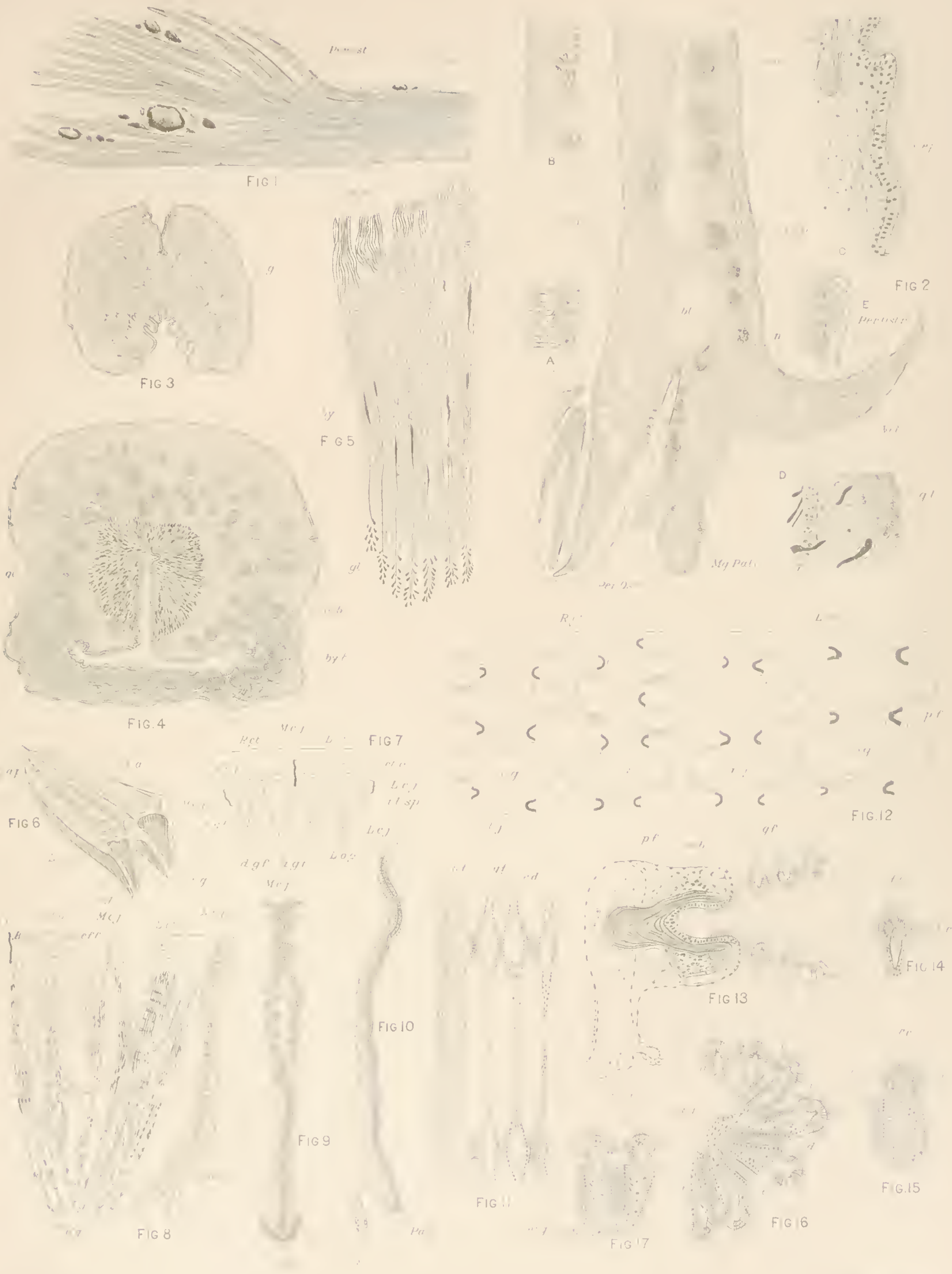
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Fig. 1
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THE PARASITES OF THE PEARL OYSTER.

BY

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AND

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[WITH FOUR PLATES.]

INTRODUCTION.

THE history of the formation of pearls in European mussels around the Cercaria of Trematodes is recorded in the papers of GARNER (1871), GIARD (1897), DUBOIS (1901) and others, and it has recently been re-told in more detail by Dr. H. LYSTER JAMESON.* The main part of Dr. JAMESON's own observation was directed to the *Leucithodendrium* (*Distomum*) *somateriæ* (LEVINSEN) of the eider-duck (*Somateria mollissima*, LINN.) and of a scoter (*Oedemia nigra*, L.), the sporocyst of which he states is found in *Tapes decussatus*, GMEL., and in the cockle, *Cardium edule*, L., whilst the tailless Cercaria infests the mussel, *Mytilus edulis*, and is the centre round which the small lustreless pearls of that mollusc are formed. It has been pointed out since that two points are still left in an unsettled condition by JAMESON's paper, viz. (1) the exact mode of origin of the epithelial sac around the parasite which secretes the pearl, and (2) the supposed transference of the parasite from the cockle to the mussel.

With regard to the history of the relationship of internal parasites to the pearls formed in the Ceylon pearl oyster, *Margaritifera vulgaris*, SCHUM.—not a true oyster but a member of the AVICULIDÆ, and so allied to the mussel, *Mytilus edulis*—we quote two short paragraphs from Professor HERDMAN's Introduction to the first volume of this Report:—

"To Dr. KELAART (1857 to 1859) belongs the honour of having first connected the formation of pearls in the Ceylon oyster with the presence of vermean parasites. It is true that Filippi, seven years before, in 1852, showed that the Trematode *Distomum duplicatum* was the cause of pearl formation in the fresh-water mussel *Anodonta*, and KÜCHENMEISTER (1856), MÖBIUS (1857),

* 'P. Zool. Soc.,' London, 1902, p. 140.

and others extended the discovery to other pearl-producing oysters, and to other parasites; but it is possible that KELAART knew nothing of these papers, and that he made his discovery in regard to the Ceylon oysters quite independently. He (and the Swiss Zoologist, HUMBERT, who was with him at a pearl fishery) found '*in addition to the Filaria and Circaria, three other parasitical worms infesting the viscera and other parts of the pearl oyster. We both agree that these worms play an important part in the formation of pearls; and it may yet be found possible to infect oysters in other beds with these worms, and thus increase the quantity of these gems.*' Thus we have KELAART, in 1859, definitely stating the possibility, in the case of the Ceylon pearl oyster, of infecting other beds with the larvæ of the pearl-producing Platyhelminthian parasites in order to increase the quantity of pearls.

"THURSTON, in 1894, confirmed KELAART'S observation, finding in the tissues and also in the alimentary canal of the Ceylon oyster, '*larvæ of some Platyhelminthian* (*flat worm*).' He figures ('Madras Mus. Bull.,' I., Plate II., fig. 1) a section showing two of the parasites encysted between the alimentary canal and generative tubes. Here the matter rested so far as the Ceylon pearl oyster was concerned."

KELAART'S work has been till recently somewhat neglected, and we therefore give in a note* the whole paragraph which deals with parasites from his last Report.†

The large number of oysters dissected during the fifteen months of Dr. HERDMAN'S and Mr. HORNELL'S expedition enable us now to furnish what is probably a fairly exhaustive list of the Entozoa of the pearl oyster, seven in number. They comprise one Cestode (*Tetrarhynchus unionifactor*, n. sp.), three Trematodes (*Muttua margaritiferæ*, n. sp., *Musalia herdmani*, n. sp., *Aspidogaster margaritiferæ*, n. sp.) and three Nematodes, *Ascaris meleagrinæ*, n. sp., *Cheiracanthus uncinatus*, and an unidentified species of *Oxyuris*.

* "I have not in this paper detailed some very interesting discoveries made since my last Report, on the Anatomy and Physiology of the Pearl Oyster, believing that they are better fitted for a treatise on the subject than to be embodied in a Report to the Ceylon Government, which must necessarily be written in popular form. However, as this Report may, like the preceding ones, fall into the hands of scientific men, I shall merely mention here that Monsieur HUMBERT, a Swiss zoologist, has, by his own microscopic observations at the last pearl fishery, corroborated all I have stated about the ovaria or genital glands and their contents; and that he has discovered, in addition to the Filaria and Circaria, three other parasitical worms infesting the viscera and other parts of the pearl oyster. We both agree that these worms play an important part in the formation of pearls; and it may yet be found possible to infect oysters in other beds with these worms, and thus increase the quantity of these gems. The nucleus of an American pearl, drawn by MÖBIUS, is nearly of the same form as the Circaria found in the pearl oysters of Ceylon. It will be curious to ascertain if the oysters in the Tinnevelly banks have the same species of worms as those found in the oysters on the banks at Arripo."

† Reprinted in the 'Proceedings of the Madras Government Revenue Department,' 17th February, 1864.

The ectoparasites of the pearl oyster consist principally of shell-boring animals which tunnel more or less extensively into the nacreous portion of the valves. Of these, the only one whose depredations are of economic importance is the boring sponge *Cliona margaritiferæ*, DENDY. The other two, the Polychæte worm *Leucodore* sp., and the Lamellibranch mollusc *Lithodomus* sp. (date-shell), are never so numerous as to constitute a serious danger to the oyster population of the pearl banks.

I. CESTODES OF THE PEARL OYSTER.

I. CESTODE LARVÆ IN THE PEARL OYSTER, *Margaritifera vulgaris*, SCHUM.

The cestode larvæ of the pearl oyster pass through several stages in the tissues of the host, that is if they escape being entombed within the centre of a pearl. Economically these unpleasant little creatures are of supreme importance to the Ceylon pearl fishery, as their presence in the oyster causes the formation of the finest quality of pearl and those with the highest lustre.

These larvæ first attracted attention during the second cruise* of the "Lady Havelock," on March 6th, 1902, and the following days, when numbers of the early globular stage were dissected out from the livers of oysters dredged from the West Cheval Paar. Subsequently, during the investigation carried out at the Galle Biological Laboratory, a second and more advanced stage of a *Tetrarhynchus* larva was found in the same animal. Details of the morphology and histology were then worked out, and the relationship which the larvæ bear to pearl formation was investigated.

It is usual for a *Tetrarhynchus* to enter its first host as an embryo enclosed in an egg-shell. As VAULLEGEARD† says, "L'œuf doit être avalé par un animal marin ; il ne se développe que si cet être lui fournit un milieu convenable, mais les Tetrarhynques paraissent peu tenir à une espèce ;" the drawings made by one of us (Plate I., fig. 1) of a free-swimming larva taken in the plankton at the north end of the Muttuvaratu Paar seems to point to the fact that the embryo of the pearl-forming parasites may leave the egg-shell before entering their first host, and this must be so if the organisms in question are truly the young of the *Tetrarhynchus;* this point, however, requires corroboration.

The earlier and more globular-shaped of the two stages met with in the pearl oyster is by far the more numerous, as may naturally be expected. It accounts for all save one per cent. of the total cases found. The liver, the gills (Plate I., figs. 3 and 4), and the connective tissue of the mantle (Plate I., fig. 2) are the organs chiefly favoured ; the muscles are practically free, while the gonads yield comparatively few.

* See "Narrative," this Report, Part I., p. 70.

† 'Mem. Soc. Normandie,' XIX., 1897 to 1899, p. 353.

In the liver and in the base of the gills they usually reach the greatest size; in the gill-filaments, where they occasionally abound, they seldom attain other than minute dimensions. Each is enveloped in a tough, elastic, and fibrous capsule of spherical form, derived from the adjacent connective-tissue cells (Plate I., figs. 5, 6, and 8). The capsules of those found in the liver and gill-bases are specially thick and strong, and slightly opalescent. In extreme cases the fibrous capsule has a thickness equal to fully half the diameter of the enclosed parasite (Plate I., fig. 5 *a*, and fig. 8 *a* and *b*).

The minute larvæ encapsuled in the gill-filaments—and these are easy of observation because of the transparency of the capsule membrane (Plate I., figs. 5 and 8)—may be seen occasionally to rotate slowly within their prison. The body is subglobular and remains so, even after considerable increase in size. The oldest larvæ however tend gradually to assume an elongated cylindrical form, with a pointed protrusible head, a denticulated collar, and a long oval body, foreshadowing the change to the rarer second or hooded larval phase (Plate I., figs. 12 and 13).

The larva in this stage closely resembles one of those figured in a paper by Professor GIARD on "L'Origine Parasitaire des Perles."* It was observed by Monsieur SEURAT, who not unnaturally mistook it for *Amphistoma*.

In the globular stage, whether minute or comparatively large, the structure differs but in details. Thus the body consists of two regions, an anterior, the smaller, and a large bladder-like posterior division. The former measures approximately but one-third of the total diameter. Viewed *en face*, this region has the appearance of a broad convexly-annular sucker, with a wide central orifice, wherefrom protrudes slightly the rounded summit of a low eminence (Plate I., fig. 9).

The saccate hinder portion of the body is thin-walled and filled with granular contents wherein rounded refractile corpuscles lie scattered abundantly, especially in the peripheral layer (Plate I., figs. 12 and 13). Under slight pressure, as first seen, it exhibited a striking resemblance to a tiny Trematode, or it might be mistaken for a large Gregarine.

When freed from its investing membranes, the larva progresses slowly by means of the alternate elongation and contraction of the body, the low central anterior eminence assisting by protrusion and retraction. The anterior region is clear and slightly tinged with yellow; the hinder is colourless and granular.

The cephalic "sucker" is in reality a head-sheath, the low median eminence within being a proboscis-like head rudiment, the scolex-rudiment (Plate I., fig. 6). When the latter is retracted—the normal condition when at rest within the cyst capsule—it lies sunk within the sheath, separated from it by a deep and narrow encircling groove. Under the influence of slight pressure, the head is seen (Plate I., fig. 11) to be shot out in the form of a blunt cone, the head groove being temporarily obliterated. The muscular walls of this cephalic apparatus, sheath as well as head,

* 'C. R. Soc. Biol.,' LV., 1903, p. 1222.

are highly developed, and consist of two series, one running longitudinally, the other in a circular manner.

The cuticle of the head and its groove is smooth ; that of the sheath is ornamented with a multitude of closely set minute shagreen-like points, resembling in shape denticles from the skin of *Scyllium* ; the central point having a tiny basal projection on either side (Plate I., figs. 10 and 11, Plate II., fig. 18).

The hinder portion of this larva is the morphological equivalent of the "bladder" of the Cysticercus stage of *Tænia*, differing however in that the contents, in lieu of being fluid, are composed of a loose connective-tissue parenchyma, in which are distributed the rounded refractile bodies already referred to. These effervesce upon the application of acid, and by this test, taken together with the similarity in appearance, they are shown to be calcareous corpuscles identical with those so widely met with among the Cestoda.

Ensheathing the body parenchyma are two muscular layers of similar arrangement to those of the head, but of extremely feeble development. These in turn are overlaid by a cuticle of peculiar appearance. In the parenchyma ramify the tubules of the vascular system.

The connective-tissue framework of the cortical region of the parenchyma is rather denser than it is in the centre. In the former, accumulating at the periphery, lie the majority of the calcareous corpuscles. Of these, while some are nearly spherical, the greater number are slightly reniform, or else obscurely compound, double, or even roughly trifoliate, shallow depressions marking some out into two or even three distinct areas (Plate II., figs. 16 and 17). With pressure, they can be broken into irregular sharp-edged fragments, just as a glass ball shatters under a blow.

The traces of a distinct and fine capsule around many of the corpuscles, which can be detected in the living tissue, is probably the remains of the cells in which the concretions arise (Plate II., fig. 17).

A closely woven network of anastomosing tubules of exceeding delicacy, suffused with the palest of pink tints, is also to be seen in the cortical parenchyma. Such represents a generalised and rudimentary excretory system which becomes specialized in succeeding stages (Plate I., fig. 12).

In the peripheral region just under the cuticle are occasionally to be made out large clear-walled cells filled with colourless transparent globules ; probably these are the "bladder-cells" which ooze through the cuticular tubules under pressure.

When a living larva is examined microscopically, the body behind the denticulated hinder portion of the head-sheath shows a distinct appearance of being clothed in a densely ciliated envelope. So distinct is the appearance, that time after time references to the "ciliated surface" of these larvæ appear in the earlier notes made on the steamer "Lady Havelock." Never however were these cilia seen in motion, and this suspicious circumstance led to a more minute scrutiny, which revealed that the appearance is due to an optical illusion. In reality the apparently ciliated layer

is an extremely delicate semi-mucilaginous external cuticular layer—the *epicuticle* as we may perhaps term it—deriving its deceptive appearance of ciliation from numerous closely-set vertical tubuli (Plate I., fig. 15). Underlying this is the thin true cuticle, perforated with pores corresponding in position and continuous with the tubules of the epicuticle. In consistence it is elastic, firm, and strong.

When one of these larvæ is being examined alive under pressure, after some time, as activity and vitality decrease, the epicuticle begins to disintegrate, delicate bladder-like cells filled with clear, colourless, oil-like globules ooze through the tubules from the sub-cuticular tissues, the mucilaginous epicuticle disappears concurrently, apparently dissolving, so that after the lapse of a few minutes the larva shows but the merest traces of this investment. The body appears then to be bounded externally by the firm and very thin true cuticle, a multitude of free thin-walled sacs full of oil-globules clustering cloud-like around the larva (Plate I., fig. 15).

In the elongated Balanoglossus-like older individuals belonging to this first larval stage, the head rudiment becomes longer and more proboscis-like; its bulk increases more rapidly than its sheath, which tends to assume a collar-like form (Plate I., figs. 12 and 13). At this stage, movements become more active, and the larva, facilitated by its more vermean form, crawls restlessly about when freed from its capsule. Histologically, the tissues show no further differentiation.

The larvæ we have described correspond so closely with the figures of those found by Monsieur SEURAT given in Professor GIARD's article mentioned above, that we think there is little doubt that they are at least generically the same. Professor GIARD identifies these as belonging to the family Monobothria of VAN BENEDEN's Order Pseudophyllidea. If Professor GIARD's identification be correct, then our larvæ also belong to this family. We have, however, found a larval stage of an undoubted *Tetrarhynchus* living in the pearl oyster, and it is not impossible, though it seems improbable, that this stage is but a later one of such of the larvæ described above as escape entombment in a pearl.

This second stage, or larval *Tetrarhynchus*, shows a great advance on the larva described above. In length it measures from 4·5 millims. to 5·5 millims., and has a sagittate outline. The body, covered with a sculptured cuticle, is sub-cylindrical, decreasing slightly in diameter at the extreme posterior extremity (Plate II., fig. 19).

The anterior end is sub-conical, furnished laterally with two hood-like lappets, which are laid back ear-like, one on either side, when the creature is quiescent. They function as organs both of progression and of adhesion. Two muscular cup-shaped depressions occur in each, constituting two pairs of simple suckers (Plate II., fig. 22). When at rest, these suckers are not apparent; but as the lappets sweep forwards, either as swimming or locomotor organs, or as organs of prehension and attachment, the pits or suckers become conspicuous and comparatively deep. The lappets are extremely mobile, changing form continuously.

The short caudal region, slightly less in diameter than the rest of the body,

terminates bluntly and is armed over the posterior moiety with stiff cilia-like hairs (Plate II., fig. 20).

The internal structure of the body is obscured by the massing of innumerable calcareous corpuscles in the cortical region. No details of the excretory system could be made out, save the presence of the main longitudinal trunks, and of a well developed terminal contractile vesicle opening to the exterior at the posterior extremity (Plate II., figs. 19 and 20), and a few loops in the head (Plate II., fig. 21).

Conspicuous within the second quarter of the body lie the four great proboscis-sacs. Each proboscis passes forwards to its point of emergence between the cephalic suckers (Plate II., fig. 22). One of their hooks is shown in Plate II., fig. 23.

The cuticle possesses a certain surface ornamentation, consisting of tiny mammillations or tubercles, irregularly disposed (Plate II., fig. 20), except upon the caudal portion, where the markings assume a meandering Greek pattern of graceful and intricate curves. The latter are possibly the expression of a post-mortem shrinkage, they were not observed in all cases, and are exaggerated in our figure.

II. Cestodes in the File or Trigger Fishes.

In looking for the second host of the pearl oyster parasites, it was natural to examine the species of *Balistes*, the Trigger or File fishes. It has been asserted, and also contradicted, that these fishes feed largely on pearl oysters and other molluscs. We have, however, confirmed the truth of the statement, having on many occasions found pearl oyster shells in the stomachs of *Balistes* taken on the banks. The presence in the body of both *B. mitis* and *B. stellatus* of numerous Tetrarhynchid cysts led to the hope that a further stage in the life history of the parasite upon which jewellers are so greatly dependent had been discovered. A more minute examination however, renders the connexion between the parasites of the pearl oyster and those of the file fish a doubtful one.

We have found so far in the *Balistes* two *Tetrarhynchi* belonging in our opinion to two distinct species, and these we have named *Tetrarhynchus balistidis* and *T. pinnæ* respectively. The latter is ensheathed in a large bladder-like vesicle, four or five times the length of the scolex, and perhaps twice as broad, the whole somewhat resembling a Lima-bean. The other form, *T. balistidis*, is also ensheathed in a vesicle, but of somewhat different form ; it has, for instance, little space between the inner and outer wall, and is simply a double membrane closely applied to the head of the scolex. It does not arise from the extreme end of the scolex, and so envelop the whole scolex, but it arises a little way behind the head and is folded forward as a woman might turn a short cape over her head. The result is that in this second form the scolex projects behind the vesicle (Plate II., fig. 24), whilst in the first the vesicle projects behind the scolex (Plate II., figs. 31 and 32).

Macerated specimens and sections show that the teeth of these two *Tetrarhynchi* are very different in shape, size and number. In *T. balistidis* the teeth are few in number, slightly curved or hooked, with a well pronounced broad base (Plate II., figs. 33 and 35). Seen in optical section, there are but two teeth visible in a transverse row, and probably each transverse ring of teeth consists of but four to six of these structures (Plate II., fig. 34). The teeth of *T. pinnæ* are, on the other hand, exceptionally numerous. They arise in two hemicircles, and the centre of each hemicircle lies posterior to the free ends. The right and left hemicircles alternate, as is seen in Plate II., fig. 37. The teeth are so numerous that the oblique \/ shape in which they are arranged is not evident when the teeth are themselves examined. Then only a forest of fine blades is seen like the clashing swords of an army acclaiming an Emperor, but if the lens be focussed on to the bases from which the teeth originate the orderly arrangement, as of soldiers drawn up in rank, becomes apparent. The teeth of this form differ from the stout teeth of *T. balistidis* not only in their number, but in their size and shape. They are smaller and far more delicate in outline, and are shaped like a Malay kriss (Plate II., fig. 36). At the proximal end is a small haft or handle, which probably represents the portion embedded in the flesh.

T. balistidis occurs encysted in the liver, and beneath the peritoneum of the spotted file or trigger fishes (*Balistes stellatus* and *B. mitis*). Its length is about 12 millims. to 13 millims., and its breadth 1·5 millims. to 2 millims. It consists of a rounded triangular head and an elongated, melon-seed-shaped body. The head is enveloped in a protective sheath—like an amnion—but remaining open at a median pore (Plate II., fig. 24). The hooked introverts and their muscular sheathes are all confined to the head, and are enveloped in the sheath. Traces of the bothria or suckers are visible. The body is quite free from the sheath and in no part surrounded by it. Both body and head are crowded with calcareous corpuscles.

What we take to be a later stage of *T. balistidis* also occurs beneath the peritoneum of *Balistes mitis* and *B. stellatus*. This stage is represented by the squarish head of a *Tetrarhynchus* with the introverts protruding and the bothria well marked (Plate II., fig. 25). This form has thrown off its body and its amnion, in fact the whole vesicle has disappeared. It shows distinct signs of 4 bothria, such as exist in *Tetrarhynchus bisulcatus*, LINTON. The introverts and their muscular sacs lie one on either side of the level of the bothria. The small papilla or protuberance at the posterior end indicates the beginning of the body or string of proglottides of the adult.

We have thus in *Balistes mitis* and *B. stellatus* in all probability two stages of the species *T. balistidis*.

T. pinnæ lies in more definite cysts formed by the pathological growth of the tissues of its host, and from which they can be easily shelled. The cysts are elongated oval or sausage-shaped, whitish or brownish-yellow in colour, and some

10 millims. to 15 millims. in length (Plate II., figs. 28, 29, and 30). The larva with the cyst is covered by a thin cuticle, beneath which lie some poorly developed circular and longitudinal muscular fibres (Plate II., fig. 38). The body of the vesicle is very fluid, consisting of a highly vacuolated parenchyma. In the parenchymatous cells numerous oil drops and calcareous bodies lie.

Finally we have a very small *Tetrarhynchus* found amongst the spiral valves of the intestine of a sting-ray, *Tæniura melanospilos*, BLKR., kindly identified for us by Mr. G. A. BOULENGER of the British Museum (Plate IV., figs. 67, 70, 71, and 72). In the stomach of this fish, known locally as the "Pulli-thirikkai," two entire and quite unmutilated *Balistes* were found. Dr. VON LINSTOW has kindly furnished us with a diagnosis of this *Tetrarhynchus*, which he has named *T. minimus*, and this we subjoin in the systematic part dealing with the Cestoda (p. 89).

Amongst the specimens of *Tetrarhynchus minimus* found in the *Tæniura* was a single example of *Polypocephalus*, a genus established by BRAUN* for some specimens he described from the stomach of *Rhinobatis granulatus*, CUV.

We have now dealt with the following forms:—

A. In the pearl oyster, *Margaritifera vulgaris*, SCHUM.—

(i.) Small Cestode larvæ in various tissues, some of these form the nuclei of pearls. These correspond very closely with the larvæ found by Monsieur SEURAT, and identified by Professor GIARD as belonging to the family Monobothria.

(ii.) Older larvæ, of the genus *Tetrarhynchus*, in more than one stage, the most mature and the most abundant of which have no sign or trace of a vesicle, the introverts protruded and probably functional, the muscular sacs of the introverts reaching back to the middle of the body, a well developed excretory system with a terminal pore, the posterior end of the body spinous, with sinuous markings, and the rest of the body covered with low warts (Plate II., fig. 20).

B. In the file or trigger fishes, *Balistes mitis*, *B. undulatus*, and *B. stellatus*—

(iii.) *Tetrarhynchus balistidis*, n. sp., whose head is closely enveloped in a vesicle which does not enclose the body, the teeth on the introvert are large and few in number, 4 to 6 in a horizontal ring (Plate II., fig. 24); a later stage of this form, like it encysted in the sub-peritoneal tissue, is represented by a squarish head with 4 bothria (Plate II., figs. 25 and 26). This stage has quite freed itself from vesicle and "body," but is provided posteriorly with a papilla or protuberance, from which the proglottides will probably arise.

(iv.) *Tetrarhynchus pinnæ*, n. sp., enveloped in a large vesicle swollen with

* 'Arbeit. Inst. Würtzburg,' IV., 1877–78, p. 297.

aqueous parenchyma. The vesicle covers the whole head and such body as exists, and in relation to the scolex recalls the Cysticercus stage of *Tænia*. The oval cysts lie embedded in the sub-peritoneal tissues. The introverts of this form have enormous numbers of weak hooks which arise from \/ shaped bases. There are but 2 bothria (Plate II., figs. 28, 29, 30, 31, 32, 36, 37, 38).

(v.) *Tetrarhynchus minimus*, v. Lins., from the spiral valve of the intestine of *Tæniura melanospilos*, Blkr., a fish which eats *Balistes* (Plate IV., figs. 67, 70, 71, 72).

C. In the sea—

(vi.) A planarian-like larva, which in the structure of its calcareous corpuscles and its cuticle recalls the embryonic forms described above.

What is the relationship of these six forms?

To begin with the last, the planarian-like larva found swimming by lateral undulations—for it is unciliated—certainly resembles the youngest forms found in the pearl oyster. The indications of the invaginated head and the presence of calcareous corpuscles strengthen the resemblance. On the other hand, we as yet know of no other Tetrarhynchid which has a free-swimming larva. *Tetrarhynchi* make their way into their first host as embryos still encased in egg-shells. The Bothriocephalidæ have however free-swimming larvæ, but these swim by cilia. On the whole, we think it probable that this larva is the first stage in the life-history of the pearl-forming organism, but until it has been observed to enter the *Margaritifera vulgaris*, and until a more minute examination by sections proves the precise nature of the larva, it would be unwise to be dogmatic.

The young larvæ within the oyster have a two-fold fate, (i) either they become the nuclei around which their own sarcophagus is secreted, or—but this is most improbable—(ii) they may grow into the older *Tetrarhynchus* larvæ. The first have no further interest for their race. They perish but to form "pearls of great price" for which men risk their lives, and, as dried-up mummies set in a costly sheath, they serve to deck the crowns of kings and the necks of fair women. Had Cleopatra, when she dissolved her Orient pearl in vinegar, examined the residue with a lens instead of drinking it, she would doubtless have found a shrivelled, dried-up particle, the mummy of a tape-worm larva, around which the pearl had been deposited.

The *Tetrarhynchi* found in the pearl oyster seem to lack but reproductive organs to be adults. The following features in these forms are of importance in considering their alleged relationship with the encysted forms found in the *Balistes*:—the presence of the 2 lappets, each sheltering 2 bothria; the absence of any kind of vesicle; the position of the muscular sheaths into which the introverts can be withdrawn, the posterior end of these lies about half-way along the body; the warty markings on the skin; and the ciliated posterior end of the body.

None of these features are reproduced in either of the *Tetrarhynchi* encysted in the tissues of the *Balistes*. The more advanced larvæ from the pearl oyster have arrived at a later stage in development than the larvæ found in the *Balistes*, and, unlike them, seem to belong to that group of the Tetrarhynchidæ which form no vesicle. The teeth on the introvert differ in all respects from those of the *Tetrarhynchi* of the *Balistes* and from another *Tetrarhynchus* sp. found in *Trygon walga*. Those of the two species from the *Balistes* differ in nearly every detail. It would be rash to make a dogmatic statement as to the future fate of the *Tetrarhynchus* of the pearl oyster. The trigger or file fishes (*Balistes*), known to the Tamil fishermen as the Kilathi, have by our own observation been proved guilty of feeding largely on pearl oysters. Fragments of pearl oysters are frequently found in their stomachs, and altogether they seem to be the most likely host for the further development of the oyster parasite. We do not, however, think that it is at present clear that they are the second or final host.

Like the pearl oysters, the infested file fishes are by no means confined to the oyster banks in the Gulf of Manaar. Our Ceylon Expedition took them at Trincomalee and again at Galle; at the latter place one was taken so infested with young *Tetrarhynchi* that the mass of their cysts equalled in bulk the whole of the stomach and intestine. A second point is that the form with the large vesicle, *T. pinnæ*, was also found in the tissues of a large *Pinna* sp., a mollusc more widely distributed around Ceylon than *Margaritifera vulgaris*.

The nature of the teeth and their arrangement in *T. minimus* argues against any relationship between the pearl oyster parasite and the small *Tetrarhynchus* found in *Tæniura melanospilos*, and this want of relationship is corroborated by its very minute size. At present the final host of the pearl-forming Cestode does not seem to be *Tæniura melanospilos*. Still the adult *Tetrarhynchi* live almost exclusively in the alimentary canal of Elasmobranchs. Other members of this order which were found in the neighbourhood of the pearl fisheries were *Pteroplatea micrura*, Bl. and Schn., and *Trygon walga*, Müll. and Heull, *T. uarnak* (Forsk.) and *T. sephen* (Forsk.). The last two species were taken by Thurston in the Gulf of Manaar. Day also records *T. marginatus*, Blyth, *T. bleekeri*, Blyth, *T. hennettri*, Müll. and Heull, *T. kuhlii*, Müll. and Heull, *T. lumbricata*, Bl. and Schn., *T. zugei*, Müll. and Heull, from the Indian and Indo-Malayan seas. Probably one of these is the host ot the final stages of the two Tetrarhynchid metacestoid larvæ found in the *Balistes*, which they certainly eat, and possibly also of the pearl-forming larvæ of the *Margaritifera vulgaris*. Linton* has described a number of *Tetrarhynchi* from various species of *Trygon*. These are *Tetrarhynchus* (*Rhynchobothrium*) *hispidus*, *T.* (*Rh.*) *longispinis*, *T.* (*Rh.*) *tenuispinis*, and *T.* (*Rh.*) *wagneri*, *T. tenuis*,† and *T. robustus*

* 'U.S. Commission of Fish and Fisheries. Commissioner's Report,' Part XV., 1887. Washington, 1891.

† The *T. lintoni* of Vaullegeard.

from *Trygon centrura*. Diesing* has also described *T.* (*Rh.*) *rubromaculatus* from *Trygon pastinaca*, and *T.* (*Rh.*) *heteromerus* from *Trygon brucco*, but the Trygons from the seas around Ceylon have yet to be investigated for their Cestode parasites. None of these *Tetrarhynchi* hitherto described from Trygons sufficiently resemble the forms described in this Memoir to warrant any claim to relationship.

Systematic Description.

The following is an attempt to draw up the systematic characters of the three Tetrarhynchids described above, but it must not be forgotten that these characters are taken from larval forms. Although the later stages of the larvæ obviously approximate to the adult condition, the characterisation of a species from a larval form is always open to objection.

Cestodes from Pearl Oyster.

1.—**Tetrarhynchus unionifactor**, n. sp., Plate II., figs. 19 and 20.

Well advanced larva, about 6·5 millims. to 7 millims. in length. Head with two lappets at the bottom of each two bothria. Introverts with teeth spirally arranged, teeth shaped as in figure, uniform in shape and size. Surface of body covered with low warts except the hindermost end, where the last thirtieth of the total body length was ornamented with coiling markings, perhaps post-mortem wrinkling. The posterior half of this region bears stiff cilia. The sacs of the introverts stretch throughout the anterior half of the body. There is no trace of vesicle.

Habitat :—In the tissues of the pearl oyster, *Margaritifera vulgaris*, Schum., from the Gulf of Manaar, Ceylon.

Cestodes from File or Trigger Fish.

The three Cestodes hitherto recorded from the genus *Balistes*, and they are all from *Balistes capriscus*, L., are :—

(i.) *Rhynchobothrium paleaceum*, Rud., which in a larval state is found in *Mullus barbatus*, L., and is a synonym of *Tetrabothriorhynchus migratorius*, Dies.† According to von Linstow's 'Compendium der Helminthologie' this species is figured in Olsson's "Entozoa, iakttagna hos Scandinaviska hafsfiskar."‡ In the explanation to the Plate, however, the Cestode is simply called a *Tetrarhynchus* without specific name.

* 'S.-B. Ak. Wien,' XLVIII.

† 'Diesing 'Systema Helminthum,' p. 573, and 'Rev. d. Cephal. Param.,' 'S.-B. Ak. Wien,' XLVIII., p. 294.

‡ 'Lund. Univ. Ars-skr.,' 1886 (IV.), Plate II., figs. 35, 36, 37.

(ii.) *Tetrarhynchus balistes-caprisci*, WAG.* Two figures are given of a *Tetrarhynchus* from *B. capriscus*, but there is no diagnosis of the species, and the figures are hardly sufficient for purposes of precise determination.

(iii.) *Cestoscolex capriscus*, PARONA, is mentioned in a list given in 'Res Ligusticæ,' II. "Vermi Parasiti in Animali della Liguria,"† but no description and no figures are given.

From the above brief résumé of the literature of the subject it seems impossible to identify the specimens at our disposal with any of those mentioned by previous writers. We have therefore made a fresh start and described the two species from *Balistes* as new.

2.—**Tetrarhynchus balistidis**, n. sp., Plate II., fig. 24.

Well advanced metacestoid larva, still retaining the body, 12 millims. to 13 millims. in length. Head triangular, enveloped by a closely wrapping vesicle which leaves the body free. Body crowded with calcareous corpuscles. Teeth of introvert few, only 4 or 6 in a transverse row, strongly hooked. Introvert sheathes confined to the head and not entering the body, which, it seems, is after a certain time thrown off (*cf.* fig. 25) with the vesicle. Apparently 4 lappets.

Habitat:—The metacestoid stage or cysticercoid occurs in the sub-peritoneal tissues of *Balistes stellatus* and *B. mitis* from Ceylon.

3.—**Tetrarhynchus pinnæ**, n. sp., Plate II., figs. 31 and 32 and 38.

The advanced larva or metacestoid is enclosed in a large vesicle, which not only covers the head, but the entire body, and is much larger than the body, 1 millim. to 15 millims. long. The teeth on the introvert are very numerous and arranged in oblique lines. Each tooth is slender, very slightly hooked, and is shaped like a Malay kriss. The proboscis sheaths extend nearly to the posterior end of the scolex. Two lappets.

Habitat:—The metacestoid larva lives in cysts in the tissues around the alimentary canal of *Balistes stellatus* and *B. mitis*, the younger larvæ probably in a *Pinna* sp. from Ceylon.

Cestodes from Sting-Ray.

4.—**Tetrarhynchus minimus**, n. sp., VON LINSTOW.—Plate IV.,‡ figs. 67, 70, 71, 72.

Length 3·7 millims., the last proglottis measures 1·6 millims. in length and 0·39 millim. in breadth. The body consists of about 6 proglottides. The scolex or head bears on its anterior third 4 roundish projections directed backwards; these

* 'Acta Ac. German,' XXIV. Suppl. 1854, p. 77, Plate XIV., figs. 179, 180.

† 'Ann. Mus. Geneva,' Ser. II., IV., 1886, p. 486.

‡ Plates III. and IV. have, by mistake, been lettered 3 and 4 in Arabic.

are the proboscis sheathes from which the proboscides are protruded (Plate IV., figs. 71 and 72). The projections bear very minute, closely packed hooks, from their apices the proboscides protrude, and these bear larger hooks at wider intervals. There is a regular gradation in the size of the proboscis hooks which is shown in Plate IV., fig. 67. The part of the proboscis which is retracted is arranged in a wavy fashion. The reproductive pore is lateral on the posterior third of each proglottis, but for the most part, only immature proglottides were present. The ova are thin-shelled, spherical, with a diameter of 0·0039 millim. This is the smallest of all species of *Tetrarhynchus*.

Habitat :—The folds of the spiral valve of the intestine of *Tæniura melanospilos*, BLKR., taken off Ceylon, at Trincomalee.

The very peculiar and regular arrangement of the teeth, and the gradation in their size and shape is a remarkable feature in the *Tetrarhynchus* from the *Tæniura*. These features seem to separate it off both from the *Tetrarhynchi* of the pearl oyster and from those of the file fish, and to bring us to the conclusion that these forms which seemed at first as if they might be stages in one life-history are really independent species, and that our knowledge of the life-cycle of the parasite which causes the formation of pearls is still incomplete.

II. TREMATODES OF THE PEARL OYSTER.

Three species of Trematodes inhabit the pearl oyster, all of them in an immature condition. They all appear to be new species and we have called them *Muttua margaritiferæ*, *Musalia herdmani*, and *Aspidogaster margaritiferæ* respectively.

1.—**Muttua margaritiferæ**, n. gen. and n. sp.—Plate III., figs. 53, 54, 55, 56 and 57.

Minute, 0·9 millim. to 0·75 millim. in length. Lanceolate shape, slightly narrower anteriorly, both ends bluntly rounded. Cuticle covered with minute pointed scales which extend over posterior end. Suckers almost equal in size, the posterior lies behind the middle of the body. No prepharynx. Pharynx medium in size, no œsophagus, the links of the alimentary canal extend to the vesicle of the excretory system, *i.e.*, almost to the posterior end of the body. Excretory vesicle large, transversely placed and somewhat basin shaped, the coils of the excretory tubules are very marked on each side of the pharynx. Genital pore to the right of the posterior sucker. The vagina is plicated, the penis is large. The cercaria stage has two black eye-spots, one on each side of the pharynx. The characters of the species are those of the genus.

Habitat :—The cercaria stage inhabits the pearl oyster, *Margaritifera vulgaris*, SCHUM. It is usually found in the gills, and is most frequently met with in those oysters which live on a rocky substratum, such as those of the Muttuvaratu Paar.

Of the three Trematodes associated with the pearl oyster, this is the only one found in any abundance; the other two species are so rare that no more than some

half-dozen individuals have been met with during the course of the present investigation.

The local distribution of *M. margaritiferæ* is noteworthy. Its Cercariæ swarm in the stunted pearl oysters of the Muttuvaratu Paar; but in those from the Eastern Cheval they are very rare. Rocky ground predominates in the former locality, sand in the latter. As a consequence the molluscan, annelidan and fish constituents of the fauna show considerable divergence, and this, in turn, influences the numbers of the two unknown animals which lodge respectively the sporocyst and the adult form of this Trematode, and thus produces the erratic local distribution noted.

These Cercarian larvæ are usually found in the gills of the pearl oyster; there they occur frequently in considerable numbers. In a fragment of gill-lamella from a Muttuvaratu individual, made up of 12 filaments, as many as 6 of these Trematodes were found. To a much smaller degree they infest the mantle. In the other organs they seldom appear.

Their abundance is strangely variable even in oysters from the same "paar." In those from the Muttuvaratu, the majority contain from 20 to 40 each; occasional individuals are, however, found infested by an extremely limited number, and in a few instances there is a total absence of the parasite. On the other hand, in the large well-grown oysters from the Eastern Cheval, during the past eighteen months it was exceptional to find even a single one.

To give an account of the life-history of the Trematode and to discover the hosts of the other stages in its life-cycle, it will be needful to anchor on the Muttuvaratu Paar for a sufficiently long period to permit of an exhaustive examination of the principal organisms that live there in association with the oysters. A lengthy visit to this particular paar is also required in order to determine whether this Trematode has any importance as a pearl-inducing factor, although, so far as present evidence goes, it is strongly against such a presumption—every one of the dozen cyst-pearls obtained from this bank which have been decalcified has yielded a Cestode larva as nucleus.

The stage of *Muttua margaritiferæ*, which is met with in the pearl oyster, is a quiescent Cercarian form of an advanced character, the alimentary canal and the copulatory organs being fully developed. What appear to be testes are also present, but no trace of ovary was detected.

The larva lies coiled or, rather, doubled upon itself (Plate III., fig. 54) within a thin membranous adventitious capsule. It frequently changes position, rotating slowly within its prison.

When liberated by the rupture of the investing sac, the body is seen to be gracefully lanceolate in outline when viewed from either the dorsal or the ventral aspect. Anteriorly it is somewhat truncate, posteriorly it narrows rapidly, ending in a blunt rounded angle (Plate III., fig. 55). In length it is remarkably uniform, 0·75 millim. to 0·9 millim. covering all the individuals measured.

The two suckers are equal in diameter, that of each equal to one-third of the width of the body at its widest part. The posterior or ventral sucker (*v.s.*) is placed just behind the middle point in the longitudinal axis, its anterior margin approximately coinciding with this point. The muscular structure of the suckers presents no unusual feature.

Transverse rows of minute spines, closely and regularly disposed, beset the cuticle. The points are directed backwards, and as a rule they alternate in position with those of the row in front. The rows encircle the body, and, being arranged with perfect regularity, they impart a distinct appearance of annulation. There are about 150 or more of these encircling rows (Plate III., fig. 57, *c.s.*).

Two black eye-spots are conspicuous, even when the larva is viewed within its capsule (Plate III., figs. 54 and 55, *e*). One lies on either side, close to the junction of the oral sucker with the muscular pharynx. The diameter of each eye is equal to the width of two of the transverse rows of cuticular spines.

A wide aperture in the centre of the oral sucker opens into its capacious funnel-shaped cavity, a chamber continually varying in size. The mouth lies at the base of this funnel, whence a short buccal passage leads directly into the muscular pharynx (*ph.*), elliptical in optical section. There is practically no œsophagus, and the two long tubular digestive cæca (*d.c.*) arise close to the pharynx. Each of these, as it passes backwards, curves outwards till it approaches close to the lateral margin, thereafter pursuing a nearly straight posterior course. The cæca terminate at a point close to the anterior border of the excretory vesicle (*e.v.*). They are never distended with food material, as happens in the case of the succeeding species; little is to be seen save a number of rather large clear globules. All the organs are, indeed, remarkably clear and free from the massing of opaque granules so frequent in many Cercariæ and which is so marked a feature of the species next to be described.

The excretory system consists of two tubular lateral trunks extending the whole length of the body. Anteriorly, in the pharyngeal region, they are much convoluted; posteriorly they empty into a capacious median vesicle which communicates with the exterior by means of a narrow funnel-shaped pore at the hinder end. The excretory vesicle varies considerably in form; sometimes, as when the larva is lying within its capsule, it is broadly ovate, the narrow end directed posteriorly (Plate III., fig. 54, *e.v.*); at other times, when the worm is crawling about after liberation, the vesicle shortens and widens, and appears as a broad transverse chamber, roughly triangular in outline, the base directed forwards (Plate III., fig. 55, *e.v.*). The epithelial cells lining its interior are very conspicuous; they consist of very large cells, markedly convex on the free surface.

Two paired glands, which appear to be the male gonads, are present. They are situated laterally, one on either flank of the ventral sucker. Each is an elongated sac, broader behind than in front, and full of densely packed cells containing numerous clear globule-like bodies. No ovary can be traced.

Both of the copulatory organs are present and well developed. They open side by side to the immediate right of the ventral sucker at about the level of its centre. That of the male consists of a great cylindrical penis-sheath (*p.sh.*) lying, in great part, posterior to the ventral sucker. It contains a well-defined seminal vesicle (*s.v.*) at the posterior end together with the rudiments of the penis itself. The distal portion of the sheath is somewhat narrowed to form a distinct neck.

The female organ, the vagina, lies to the right, alongside and parallel with the penis-sheath. The walls are thrown into a number of circular folds or pleats—wide grooves, concave in section, alternating with sharp-angled encompassing projecting folds—that give it much the appearance of a broadly spindle-shaped Chinese lantern. No trace of uterus can be made out.

The encysted cercariæ of this Trematode resemble those figured and described by JAMESON in some features, but differ from them in other particulars, which indeed exclude it from the sub-family Brachycoelinæ to which *Leucithodendrium* belongs, *e.g.*, the two branches of the alimentary canal extend far beyond the ventral sucker, and indeed reach almost to the hinder end of the body.

It is difficult to establish a new genus upon a form which is not yet adult, but after going through the twelve sub-families into which LOOSS* has split up the Distomidæ we cannot bring our specimens into line with any of them. Some of their characters appear in one sub-family and some in another, but the totality of characters does not appear in any one of them. Owing to the immaturity, several of the chief features of the adult anatomy, such as the disposition of the uterus, could not be made out.

The increasing difficulty of coining names hitherto unoccupied has induced us to fall back on Tamil, and we suggest the name *Muttua* (Muttu means a pearl) for the genus. This will recall the particular paar (Muttuvaratu) where it occurs in the greatest abundance.

2.—**Musalia herdmani**, n. gen. and n. sp.—Plate III., fig. 51, and Plate IV., figs. 58, 59, and 65.

Skin smooth, without denticles. Pharynx rather smaller than oral sucker. Ventral sucker very large and protrusible; its diameter, as compared with that of the oral, is as 7 : 3. Œsophagus very short, a median backward pouch projects between the origin of the two limbs of the alimentary canal. The latter are long and reach back to the end of the body. The reproductive openings lie between the ventral sucker and the oral, but nearer the latter. The testes lie behind the ventral sucker and are inclined at an angle one to another, the ovary lies behind them. Excretory bladder small and triangular.

Habitat :—The larval encysted stage is found in *Margaritifera vulgaris*, SCHUM., encapsuled in the muscles, the mantle, and the foot.

* 'Zool. Jahrb. Syst.,' XII., 1899, p. 522.

This species is exceedingly rare in the pearl oyster. Four individuals only have been found, two from oysters hailing from the Periya Paar Kerrai, and a like number from the Muttuvaratu. Both of the former were found in the muscular pallial region in front of the base of the foot (Plate IV., fig. 65) in separate oysters. Of the others, one lay in the floor of the visceral mass, the other in the posterior ventral region of the mantle.

As in *Muttua margaritiferæ*, the stage met with had the outward form and the rudiments at least of all the organs of the adult individual. The specimens found were, however, not sexually mature, and being in an encysted condition must be considered as a Cercaria. Their length when in a normal non-contracted condition is $\frac{1}{8}$ of an inch (3 millims.). They are of an elongated narrow lanceolate shape, with a ratio of length to breadth of about 6 to 1 (Plate IV., figs. 58 and 59).

The cuticle is perfectly smooth, without denticles or ornamentation of any description.

The suckers are of greatly disproportionate size, the ventral rather more than twice the diameter of the oral (ratio of 7 : 3). The former (*v.s.*) is rendered further conspicuous by being pedunculate, rising boss-like from just behind the centre of the body. The peduncle is rather longer than half the diameter of the sucker (Plate IV., fig. 58). It has a large degree of mobility.

When *in situ*, and also when freed from its capsule, to the naked eye the worm appears of a pale pink tinge; under a low power of the microscope this is resolved into a dark yellow coloration confined to the œsophagus and wide digestive cæca of the alimentary canal. The only other colour present, when viewed by transmitted light, is the black of the narrow excretory trunks.

The mouth is situated at the bottom of the funnel-shaped cavity of the oral sucker (Plate IV., fig. 59, *o.s.*). It opens almost immediately into the short muscular pharynx (*ph.*). A rather wide aperture admits in turn to a peculiar saccate, subglobular œsophagus (*œ.*) which gives off laterally and dorsally a branch on either side. These pass outwards, at right angles, for a short distance, then, turning posteriorly, they are continued as very wide blind sacs, the digestive cæca (*d.c.*) as far as the anterior border of the excretory vesicle (*c.v.*). A great mass of yellow granules distends both œsophagus and digestive cæca, imparting a characteristic deep yellow hue to the digestive system. By reason of their great bulk these organs occupy the major portion of the body of this worm—a condition contrasting notably with the transparent and practically empty state of the alimentary canal in *Muttua margaritiferæ*.

The main trunks of the excretory system (*ex.tr.*) are two narrow tubes, black by reflected light, coursing backwards in sinuous manner from the pharyngeal region, one on either side. Posteriorly they empty into the slender pyriform excretory vesicle (*c.v.*), transparent and contractile. The products of excretion pass to the exterior by a terminal excretory pore (*ex.p.*).

It is probable that this species is protogynous, for while the testes are as yet empty, the ovary is densely packed with granular tissue. In the present resting condition the former organs appear as two paired ovoid sacs, clear, and with no distinguishable contents. They lie immediately posterior to the ventral sucker. Behind the left testis lies the globular ovary, opaque with the mass of its crowded granular contents.

The copulatory organs lie near the anterior end of the body. They open side by side just behind the œsophageal dilatation. The penis-sheath (*p.sh.*) has a nearly median position; the vagina lies a little to the left. The former is cylindrical, showing the rudiment of a seminal vesicle (*s.v.*). The vagina is slightly curved and appears to have glandular walls. The uterus (*ut.*) is barely distinguishable in pressure preparations as a long, transparent coiled tube running from the base of the vagina backwards to connect with the ovary. Vasa deferentia are not to be made out.

In many respects this larval form conforms to the characters of Looss' sub-family Philophthalminæ.* It is a larval form, so that the difference in size is immaterial. More important is the fact that the testes in the new species are, roughly speaking, on a level, not one behind the other, and that they are before, and not behind the ovary, as they are in the Philophthalminæ. The members of this family live, according to Looss, "An geschützten Stellen der Körperoberfläche bei Vögeln."

Until we have succeeded in tracing the life-history of this form, it would be unwise to dogmatize as to its systematic position. We have, however, little doubt that it is a new genus; and we have named it after Musali, the district of which the pearl fishery coast is part. The Adigar of Musali is the native official responsible for all details when a fishery camp is being organized. The present holder of the office, Mr. V. Vraspillai, typifies everything that is best in the headman system in vogue in Ceylon.

3. **Aspidogaster margaritiferæ**, n. sp.—Plate IV., figs. 60, 61, 62, 66, 68, 69.

Length in immature specimens 6 millims., colour brown ochre dorsally, but the foot has a beautiful rose-red hue. Four rows of alveoli or suckers on the foot arranged alternately; the number of alveoli is not precisely known, it probably increases with age, but there are something like 20 in the outer rows and 18 in the two median rows. A number of "tube-feet" project from the area between the outer rows and the middle rows and between the two central rows. There are none on the outer side of the outer rows.

Habitat.—Pericardial cavity of *Margaritifera vulgaris*, Schum. Taken at the Cheval Paar, Ceylon.

Three specimens of this Trematode, closely related to *Aspidogaster conchicola*, were found within the pericardial chambers of pearl oysters from the south and south-east

* 'Zool. Jahrb. Syst.,' XII., 1899, p. 586.

areas of the Cheval Paar. They were pinkish red to the naked eye, and of comparatively large size, quite ¼ inch (6 millims.) when extended. From its distinctive habitat, we may appropriately apply the name *margaritiferæ* to this species.

The body is composed of two distinct regions, an anterior neck-like portion, slender and cylindrical, bearing oral sucker and mouth at the free extremity, and a posterior stout region which spreads laterally, on the ventral aspect, into a broad, oblong, pedal disc, armed with rows of numerous sucker-pits and short, digitate tube-feet (Plate III., figs. 49 and 50, and Plate IV., figs. 61 and 66). The dorsum is minutely wrinkled or annulated transversely (Plate IV., fig. 62).

The oral suctorial apparatus (*o.s.*) is not of the definite rosette form typical of *Distomum;* it appears as a transverse slit bounded by thin mobile lips. The lips divaricate when about to make adhesion, as in the manner characteristic of an ordinary lipped sucker.

Careful examination during life showed the pedal disc (*p.d.*) to possess a wonderfully complex structure. The surface is excavated into numerous cup-shaped hemispherical pits, associated with which are numbers of small tube feet of remarkable characteristics. Both series are arranged with perfect regularity. The shallow pits or suckers (*s.p.*) are disposed in four longitudinal rows, the individual pits of one row alternating with those of the adjoining, an economy of space which permits the accommodation of the largest possible number of pits (Plate IV., figs. 60 and 61). The mouth of each sucker-pit is simple, bordered by a membranous edge containing muscular elements. When the animal is detached from its hold, the apertures are frequently seen to close by an approximation of the muscular margin. In most cases the edges meet in a tri-radiate manner; in others the lips close upon a single slit, the axis of this being at right angles to the adjacent margin of the pedal disc (Plate IV., fig. 62).

The tube-feet project from the angles between the sucker-pits, forming therefore three double ranks of feet disposed in zig-zag pattern (Plate III., fig. 52, Plate IV., figs. 61, 66, and 68). There are none along the margin of the pedal disc. They are hollow, thin-walled, and tubular, capable of great extension and of complete retraction by inversion, in manner similar to the eversion and retraction of the proboscides of *Tetrarhynchus.* They are hollow erectile organs of the simplest structure, possessing the power of extension in an extraordinary degree. When fully extended, they assume the form of slender cylinders tapering very gradually to an acuminate apex (Plate III., fig. 52, Plate IV., fig. 68). Partially retracted, they exhibit a closely annulated or wrinkled appearance, reminding one of the annulation of an earthworm, the anterior extremity of which they greatly resemble. When drawn in more fully, they show as low truncate pillars or stumps.

The alimentary canal is median and unbranched, ending blindly near the posterior end of the body. The mouth, situated at the base of the oral sucker-slit, leads into a short narrow buccal canal opening into the strongly muscular pharynx (*ph.*) oblong

in optical section. Immediately behind this is a thin-walled vesicle representing the œsophagus. From this issues the long unbranched, thick-walled digestive cæcum (*d.c.*).

The excretory system is more highly specialized than in the two Distomids already described. As in them, it consists of a lateral trunk system opening behind into a contractile vesicle. In place, however, of arising in the pharyngeal region and passing backwards direct to the contractile vesicle, each trunk is doubled and consists of a proximal and a distal section. The proximal, which receives numerous branch feeders in its course, arises in the posterior portion of the body, close to the termination of the digestive cæcum. Thence it runs forwards to the anterior end of the pharynx, where it loops and turns upon itself, passing backwards over nearly the same course as it came. As it goes it coils around the primary or proximal portion. Both divisions are richly ciliated, a current is observable passing forwards in the cavity of the proximal limb, towards the hinder end in the other, or the distal limb. Another (third) tube or band is very faintly visible running longitudinally. Possibly it is a sexual duct.

The only specimen which could be spared to the knife was immature. There is a median aperture just between the pharynx and the anterior end of the foot. The penis is well-marked, the testis is single and so is the ovary, both lie in a mass of parenchyma which is separated above from the mass in which the alimentary canal lies, and below from the foot by two sheets of muscles. No vitellaria, uterus, or LAURER'S canal were distinguishable.

A pale smoky yellow tint suffuses the entire body, saving in the tissues lying dorsal to the tube-feet, where a warm brick-red tint is distinctive. The tube-feet appear to be colourless.

When one of these *Aspidogasters* is extracted alive from the pericardium, it exhibits an active and restless disposition, crawling freely about in a watch-glass. Its habit when thus isolated is to attach itself firmly by the suckers of the pedal disc and to wave the long neck-like anterior region from side to side, upwards and downwards, after the manner of a leech scenting or searching for prey, swaying to the extreme right, back almost to the posterior end of the body, then swiftly swinging round it repeats the search upon the left side, then forwards and above (Plate IV., figs. 61 and 69).

The manner of progression resembles that of a leech. Making adhesion over the whole of its ventral sucking disc, the mouth rises from the surface to which it has till now adhered ; the neck stretches forwards, lengthening to the utmost, it curves downwards, the lips part, and the oral sucker makes a fresh adhesion (Plate IV., figs. 69). The posterior portion of the body is next drawn forwards, the anterior suckers of the disc remaining fixed the while ; then, where the posterior region is well shortened, the whole of the ventral disc is freed and drawn along to the point where the oral sucker is fixed, when the disc re-attaches first at the anterior end and

then posteriorly. Thus the animal moves one step forwards and is brought back to the attitude it had at the beginning.

In BRONN'S Trematoda, BRAUN enumerates four species of *Aspidogaster*, viz., *A. conchicola*, v. BAER, *A. limacoides*, DIESING, *A. insignis*, LEDIZ, and *A. macdonaldi*, MONT. In his recent revision of the family Aspidobothridæ, NICKERSON* places the third of these, *A. insignis*, in the genus *Cotylaspis*, thus reducing the number of species of *Aspidogaster* to three. Of these three our species is most clearly allied to *A. macdonaldi*, inasmuch as these two species, and these two species alone, are provided with the remarkable "tentacles" or "tube-feet" which project between the suckers of the foot. It however differs from this species in the following particulars:—(i.) MACDONALD'S specimens were tallowy in colour, while ours are of an ochreous brown with a deep, rose-pink foot; (ii.) MACDONALD'S specimens were $\frac{1}{8}$ inch to $\frac{1}{10}$ inch in length, ours are $\frac{1}{4}$ inch long; (iii.) MACDONALD mentions "cæca" in the intestine of *A. macdonaldi*, ours have a simple alimentary canal, possibly MACDONALD has made a mistake in this respect; (iv.) MACDONALD records some 180 tentacles and some 120 alveoli or suckers, the numbers in our specimens are fewer; (v.) MACDONALD found his specimens "creeping about in the respiratory siphon of a large *Melo*, or melon-shell, in Shark Bay, Western Australia," our specimens occurred in the pericardial chamber of *Margaritifera vulgaris*, SCHUM., on the Cheval Paar, Ceylon.

At the end of his paper NICKERSON raises the question as to whether MACDONALD'S species does not deserve generic rank. If it does it carries our species with it. The chief generic character would be the possession of the tentacles or "tube-feet." At present, and until more specimens have been investigated and until we know more of the life-history, it seems wise to regard these forms as well-marked species of *Aspidogaster*.

III. NEMATODES OF THE PEARL OYSTER, AND OF THE FILE FISH.

The only previous record of a Nematode from the pearl oyster that we have been able to find is in a list by Dr. L. ÖRLEY of the Nematodes in the British Museum,† where the name appears of *Ascaris meleagrina*, KOLLAR, from the pearl oyster. VINCENZ KOLLAR wrote almost exclusively on insects, and we were unable to trace any reference to this Nematode in such of his writings as we have been able to inspect. We therefore applied to Mr. C. D. SHERBORN for help. Together with Professor F. JEFFREY BELL, he very kindly made an inspection of ÖRLEY'S MS.,

* 'Zool. Jahrb. Syst.,' XV., 1901 to 1902, p. 597, NICKERSON makes no mention of *A. vallei*, STORS, described in a Memoir I have not seen, from the œsophagus and stomach of *Thalassochelys caretta* (M. STOSSICH, 'Appunti di Elmintologia').

† 'Ann. Nat. Hist.,' IX., 5th Series, 1882, p. 310.

where the name KOLLAR occurs, but when this was compared with W. BAIRD'S copy of GRAY'S Catalogue, a note in BAIRD'S handwriting was found containing the words *Ascaris meleagrina*, KELAART. There seems little doubt that ÖRLEY miscopied KOLLAR for KELAART. We have not, however, been able to find any diagnosis in the reports of KELAART, or any figure of this animal which would enable us to recognize the species, and so it seems that the name is a *nomen nudum*.

Three species of Nematoda, representing as many genera, *Oxyuris*, *Ascaris*, and *Cheiracanthus*, were found in the pearl oysters on this expedition.

The *Oxyuris* was met with but twice, and both specimens were unfortunately lost. They measured barely $\frac{1}{8}$ inch in length. They were found in the intestine of the pearl oyster. The other two species were found encysted in the tissues of the pearl oyster. These were kindly examined for us by Dr. VON LINSTOW, who identifies one as new. The specimens which reached England, and which were submitted to him, were both larvæ. Dr. VON LINSTOW has been good enough to give us the following descriptions :—

Ascaris meleagrinæ, n. sp.—Plate III., figs. 42 and 43.

The greatest length is 29 millims., the breadth is 0·55 millim. On the anterior end there are 3 lips, of these the dorsal one is round, with 2 large papillæ directed forward ; on the anterior edge a row of small teeth or projections occur, and between the 3 chief lips lie 3 secondary and much less prominent lips. The cuticle is regularly ringed. The œsophagus is $\frac{1}{8 \cdot 13}$ of the total length, and the conically pointed tail is $\frac{1}{116}$ of the same. A pair of anal glands occurs in the end of the alimentary canal.

Habitat :—The larva in the tissues of the pearl oyster *Margaritifera vulgaris*, SCHUM., the adult in the intestine of the file fishes *Balistes mitis* and *B. stellatus*.

This Ascarid is usually found within the gonad of the pearl oyster, less frequently within the tissues of the mantle, in all cases in an encysted condition. It appeared, in life, transparent and slightly yellowish to the naked eye. Under the microscope, the intestine is seen to be a brownish-yellow tint. The surface of the body is distinctly and closely annulated.

In the pearl oyster, its primary host, this Nematode does not attain sexual maturity, remaining encysted and immature so long as this host lives. The mature stage is reached only after the pearl oyster, happening to be devoured by one of the oyster-eating species of file fishes—usually *Balistes mitis* or *B. stellatus*—suffers digestion within the stomach of the fish. Being thus set free, the Ascarid finds its way into the intestine and attains there eventually a notably larger size than when in its primary host, the pearl oyster.

Statistics and Details.—Out of 24 pearl oysters, 3 to $3\frac{1}{2}$ years old, from the Periya Paar Kerrai, dissected on 7th November, 1902, as many as 10 contained 1 each of this Ascarid. The cysts were lodged chiefly in the gonad in the immediate vicinity of

the stomach, most to one or other side, a few above the roof of this organ. One individual was found beneath the mouth in the substance of the labial palps.

Out of a further lot of 16 dissected on 7th November, 1902, and coming from North-east Cheval Paar, 5 contained this species of Nematode. As many as 5 of these worms were found in one individual; 3 were within the gonad, a fourth was contained in a large cyst in the palpar region of the mantle close to the pallial line.

In a second pearl oyster, 2 Nematodes were found in the gonad. A third and fourth each had one encysted in the same region, while in a fifth the Nematode cyst was in the mantle.

On 14th November, 1902, 43 pearl oysters from South-west Cheval yielded but 3 individuals harbouring this parasite, found in each case in the gonad. In another lot, one individual had one of these Ascarids in a cyst in the antero-ventral region of the mantle.

On 5th November, none were found in 30 oysters from South-east Cheval, and on 6th November, none in 15 oysters from the same.

On 11th November, two out of 20 dissected oysters from North-west Cheval yielded each 1 Nematode from the gonad.

On 12 November, 20 oysters from West Cheval gave but one, which contained this parasite. It was encysted within the wall of the stomach.

On 15th and 16th November, none were found in 61 pearl oysters from South-east Cheval.

On the 18th and 20th November, none were yielded by the dissection of 55 individuals from the Dutch Modragam and Muttuvaratu Paars.

On 3rd and 4th February, 1903, 5 individuals out of 83 dissected oysters from South-east Cheval showed 1 Nematode each in the gonad.

On 8th and 13th February, 1903, 3 oysters only were infected out of a lot of 120 dissected from North-east Cheval, in each case the cyst was within the gonad.

Of 15 oysters dissected on 11th February, 1903, from Periya Paar Kerrai, 1 only yielded an Ascarid, found in the usual position.

On 12th February, 1903, 32 oysters from the North Cheval contained no trace of this worm.

Of a total of 534 pearl oysters dissected specially in search for Nematodes, 30 individuals yielded specimens of this species.

The cysts were usually of distinct pyriform outline, flattened laterally. Occasionally the form was irregular.

Cheiracanthus uncinatus, MOLIN.—Plate III., figs. 41, 44, 45, 46, 47, and 48.

Echinocephalus uncinatus, MOLIN, 'Denk. Ak. Wien,' XIX., 1861, 2nd Abth., p. 311.

This Nematode was also in a larval state. The specimens averaged 12 8 millims. in length and 0·43 millim. in breadth. The cuticle is swollen. On the thickened

head end are 6 rows of about 50 hooks about 0·031 millim. long. The head-lappets are rounded behind and abut on one another in the lateral line. There are 6 lips on the head. The œsophagus is $\frac{1}{45}$ of the entire length, and the conically pointed tail end is $\frac{1}{54}$ of the total length. Four tubes lie beneath the anterior end of the œsophagus; these are 2·05 millims. in length, and, as is characteristic for the genus *Cheiracanthus*, these are shorter than the œsophagus and show externally a layer of spiral muscles. The larvæ were found encysted in the adductor muscle.

The adult of these forms is in all probability the *Cheiracanthus uncinatus*, described and figured by Molin under the name *Echinocephalus uncinatus*. It is found in the alimentary canal of *Trygon pastinaca* and of *Trygon brucco*.

This second Nematode infesting the pearl oyster is a robust species, readily distinguishable at sight from the Ascarid, by its comparative shortness and the sub-globular enlargement of the cephalic extremity, which is armed with 6 concentric rings of backwardly-directed spines (Plate III., figs. 41, 44, 45). This globular cephalic inflation is characteristic, but at times it appears in a deflated condition, as shown in Plate III., fig. 45, when the form becomes that of a truncated cone.

To the naked eye it appears when lying in its cyst of a faint pinkish tint, under magnification the alimentary canal is seen to be of a dirty pale-yellow hue. The colourless transparent tissue lining the body wall has a distinct areolar appearance, due to the presence of large saccate cells. The body is smooth, with no trace of annulation.

This Nematode favours exclusively as its habitat the substance of the adductor muscle, lying coiled up therein in an ovoid cyst. Plate III., fig. 47, shows some of the usual regions in the muscle where it is found. Its occurrence is strictly limited to this particular organ, but occasionally it would appear to become freed from its envelope and to leave the muscle, as instances occurred of this species being entombed in the nacreous lining of the shell. In several cases the covering film of nacre obscured scarcely anything of the outer form of the worm's body, the globular head and curved and pointed tail being especially conspicuous.

Later stages have been found by one of us in the trigger fishes *Balistes mitis* and *B. stellatus*, both pearl oyster-eating species, as proved by the presence of the shell fragments in the stomach.

This spinous-headed Nematode is found both in the alimentary canal and in the visceral cavity of *Balistes*. In the latter case, where it is much the more frequently found, it burrows in the peritoneal membranes and adjacent connective-tissue. Judging from this habitat, it would appear to use its spine-armed cephalic extremity as a burrowing organ.

It is most probable that the adult also lives in some species of *Trygon* which are known to feed on file fish, and also on pearl oysters.

Statistics and Details.—In all the cases noted below the Nematode was found in the adductor muscle—one Nematode in each case (Plate III., fig. 47).

Nov.	5th,	1902.	One infested	out of		30	dissected	from the	South-west Cheval.
,,	6th	,,	None	,,	,,	15	,,	,,	South-east Cheval.
,,	6th	,,	,,	,,	,,	8	,,	,,	East Cheval.
,,	7th	,,	,,	,,	,,	16	,,	,,	North-east Cheval.
,,	7th	,,	,,	,,	,,	24	,,	,,	Periya Paar Kerrai.
,,	11th	,,	One	,,	,,	20	,,	,,	North-west Cheval.
,,	12th	,,	,,	,,	,,	20	,,	,,	West Cheval.
,,	14th	,,	Two	,,	,,	16	,,	,,	S.W. Cheval.
,,	14th	,,	None	,,	,,	27	,,	,,	,, ,, (another locality).
,,	15th	,,	One	,,	,,	31	,,	,,	South-east Cheval.
,,	16th	,,	Two	,,	,,	30	,,	,,	,, ,,
,,	18th	,,	None	,,	,,	17	,,	,,	Dutch Modragam.
,,	20th	,,	,,	,,	,,	38	,,	,,	Muttuvaratu Paar.
Feb.	3rd,	1903.	One	,,	,,	8	,,	,,	South-east Cheval.
,,	3rd	,,	Fifteen	,,	,,	60	,,	,,	,, ,,
,,	4th	,,	Three	,,	,,	15	,,	,,	,, ,,
,,	8th	,,	Six	,,	,,	70	,,	,,	North-east ,,
,,	11th	,,	One	,,	,,	15	,,	,,	Periya Paar Kerrai.
,,	12th	,,	Three	,,	,,	32	,,	,,	North Cheval.
,,	13th	,,	Four	,,	,,	50	,,	,,	North-east Cheval.

Thus in all 41 individuals had the adductor muscle infested by this Nematode out of a total of 542 pearl oysters dissected specially in search of this parasite. In one of those of February 4th, the worm lay upon the surface of the muscle on the ventral aspect. In only one instance were two Nematodes found in the same muscle—never a greater number.

In the intestine of *Tæniura melanospilos* was found a fragment of a Nematode which was undeterminable, and a number of the species *Ascaris pastinacæ*, Rud., which inhabits also *Trygon pastinaca*, Cuv.

EXPLANATION OF THE PLATES.

PLATE I.

Fig. 1. Planarian-like free-living organism, possibly the larva of a species of Cestode, taken in the plankton on Muttuvaratu Paar, 19th November, 1902. It is most probably of the same species as the encysted larvæ found so abundantly in the pearl oysters of the paar named. Actual length when elongated, 0·37 millim. The rudiment of what may be the proboscis is already apparent. *a–h*, show various specimens in various attitudes; *c.c.*, calcareous corpuscles; *cut.*, the thick mucilaginous cuticular layer; *Pr.*, possible rudiment of a proboscis.

,, 2. Three fragments *a*, *b*, and *c* of the distal or marginal region of the mantle of a pearl oyster, showing Cestode cysts scattered in the intermuscular connective-tissue. Natural size. *Mg.Pall.*, pallial margin; *Mg.vel.*, velar margin; *T.cy.*, Cestode cysts.

,, 3. A Cestode cyst (*cy.*) in an interlamellar junction at the base of a branchia. × 3 diameters.

,, 4. Fragment of a branchia of a pearl oyster showing encysted larval Cestode (*cy.*). × 12 diameters.

,, 5. *a.* Nucleus of a "fine" pearl from the posterior ear region of a Cheval Paar oyster. The proboscis sheath and the central pit within which the proboscis is retracted are clearly shown. *k.* A "fine" pearl, showing distinct resemblance in outer form with the characteristic appearance of a Cestode larva (see fig. 5, *i*), viewed anteriorly; *c*, the same viewed laterally; *d* and *e*, natural size of the same. *i.* Outline of a young Cestode larva for comparison with the preceding. *f.* An elongated pearl, also having resemblance in outline to a Tetrarhynchid larva. *h.* Natural size of same. *l.* A lenticular pearl having an equatorial band of brown prismatic pearl-substance.

,, 6. Section through an encysted larva of about the same shape as that represented in fig. 4. The rostrum or proboscis (*a*) is still retracted in the body.

,, 7. *a* and *b*, two of the later larval stages of the Cestode met with, in encysted condition, in the tissues of the pearl oyster. Compare with fig. 13. × 80 diameters.

,, 8. A. A partially calcified Cestode cyst from the muscular pallial region of a 3-year old oyster from the Muttuvaratu Paar. The larva was dead and slightly changed in outline—partial disintegration having taken place. In colour it was dirty yellow. In the outer layers (*b*) of the cyst capsule a deposit of lime salts had begun. B. Another cyst. *b.* The outer layers of cyst; *c.* Nucleus, obtained by decalcification, of a fine pearl from the muscular pallial region of a pearl oyster from the Cheval Paar. C. Nucleus of another "fine" pearl from the ventral pallial region of a pearl oyster from the same locality as before; *d.* a few calcareous corpuscles seen within the larva as solution brought the character of the nucleus into view. D. The innermost of the membraneous laminæ left after solution of the corresponding pearl coats; *c*, a dead Cestode larva forming the actual nucleus; a ball-shaped calcification within the Cestode larva is seen. (Weight 195 milligrs.)

,, 9. Very young Cestode larva extracted from a thick-walled cyst in the mantle of a pearl oyster. × 50 diameters. (NOTE.—The outer layer is *very faintly* seen under a low power, and has an appearance closely resembling ciliation. The distal limit is not so strongly marked as shown here, see fig. 10.) *c.c.*, calcareous corpuscles; *Pr.*, proboscis; *Pr.sh.*, proboscis sheath.

,, 10. Young Cestode larva extracted from a cyst within the mantle of a pearl oyster. It shows the minute denticulation of the proboscis collar. × 25 diameters.

,, 11. The same, seen under slight pressure, whereby the proboscis, *Pr.*, has been evaginated forcibly. *Pr.sh.*, proboscis sheath. × 25 diameters.

Fig. 12. Another larva of the same stage, seen under slighter pressure, and higher magnification. × 40 diameters. The vertically striated mucilaginous cuticle is clearly shown, together with a network of anastomosing vessels. *Cut.*, cuticle; *Ex.p.*, excretory pore.

,, 13. Shows the beginning of the change from a spherical to an elongated form of body. Taken from a cyst from the viscero-pedal mass of the pearl oyster.

,, 14. Portion of same larva seen in optical section at region of proboscis collar, showing a fragment of the anastomosing network of vessels and the large bladder-like cells full of clear globules, lying beneath the dermal layer (semi-diagrammatic). The calcareous corpuscles are omitted for the sake of clearness. *Den.*, denticles; *Par.*, sub-dermal bladder-like cells; *Pr.sh.*, proboscis sheath; *Ves.*, anastomosing vessels.

,, 15. *a.* Optical section of body-wall of a Cestode larva from the pearl oyster, showing the normal appearance. *b.* Final stage, when, under continual pressure, the mucilaginous cuticular layer has disintegrated, its place being taken by one or two layers of the bladder-like cells, which thus come to invest the body of the larva. *c.* The same as *a* under slight pressure; an invasion of the delicate cuticular layer by bladder-like cells full of clear globules is in progress.

PLATE II.

Fig. 16. Forms of the calcareous corpuscles found in the larvæ of *Tetrarhynchus unionifactor.*

,, 17. The same, enclosed in the cells that secrete them.

,, 18. Form of denticles which ornament the proboscis collar of the early larva of *Tetrarhynchus unionifactor.*

,, 19. The oldest larval stage of *Tetrarhynchus unionifactor* met with in the tissues of the pearl oyster. *Arm. cil.*, armature of stiff cilia around excretory pore; *cs.*, one of the two pairs of cephalic suckers; *Ex.o.*, external orifice of excretory system; *Pr.*, protractile proboscides; *Tr.ex.*, lateral trunks of excretory system.

,, 20. Surface view of the posterior extremity of the same individual on an enlarged scale.
a. Shows the warted pattern of the whole surface of the body, except at the extreme posterior extremity, where, as shown (*b*), the surface marking becomes sinuous; other letters as in fig. 19.

,, 21. A loop of the excretory network in the cephalic region of the same individual.

,, 22. Anterior extremity of an individual of the same stage as that depicted in fig. 19 seen under greater magnification. *Pr.sh.*, sheath of proboscis; *Ret.m.*, retractor muscle of proboscis.

,, 23. One of the hooklets from a proboscis.

,, 24. A larval form of *Tetrarhynchus balistidis* from the liver of a *Balistes*, sp. × 16 diameters. *C.c.*, calcareous corpuscles; *Tr.ex.*, excretory trunks. The natural size is shown by the small figure to the right.

,, 25. Sub-spherical larva of *Tetrarhynchus balistidis* found in oval and in rounded cysts beneath the peritoneum of *Balistes*, sp.; *Pr.pro.*, proboscis protruded.

,, 26. A slightly older example of the same.

,, 27. Natural size of a cyst of *T. balistidis* from abdominal cavity of a *Balistes*, sp.

,, 28. Cyst from peritoneum of *Balistes*, nat. size, containing *T. pinnæ.*

,, 29. The larval *T. pinnæ* freed from cyst membrane. Nat. size.

Figs. 30, 31, 32. The same, under higher magnification. *C.c.*, calcareous corpuscles; *Cy. mem.*, cyst membrane; *Pr.ret.*, proboscides retracted; *Sc.*, scolex.

Fig. 33. Teeth of *T. balistidis*, isolated by maceration and highly magnified.

,, 34. Teeth of *T. balistidis in situ* on the introvert.

,, 35. More teeth of *T. balistidis* for comparison with fig. 36.

Fig. 36. A single tooth of *T. pinnæ*.

,, 37. A portion of the introverts of *T. pinnæ*, showing the oblique rows with enormous numbers of weak teeth.

,, 38. A section through the head, cut in two places, and showing the four proboscides and the bladder, with widely separated walls, of *T. pinnæ*, magnified to the same extent as figs. 39 and 40.

,, 39. A section through the head, cut twice, and the bladder of *T. balistidis* showing the four introverts, magnified to the same extent as fig. 38.

,, 40. A section through the same, showing the junction of the head with the inner wall of the bladder.

PLATE III. (3 on Plate).

Fig. 41. Head end of *Cheiracanthus uncinatus*. *gl.*, glands; *int.*, intestine; *l.*, lip; *œ.*, œsophagus.

,, 42. Tail end of *Ascaris meleagrinæ*. *a.gl.*, anal glands; *int.*, intestine.

,, 43. Head of *Ascaris meleagrinæ*, seen from above.

,, 44. Head end of *Cheiracanthus uncinatus*, inflated. × 30.

,, 45. The same collapsed.

,, 46. The whole worm, *Cheiracanthus uncinatus*. × 6.

,, 47. Diagrams showing usual position of *Cheiracanthus uncinatus* within the adductor muscle. Natural size.

,, 48. Posterior extremity of *Cheiracanthus uncinatus*. × 30.

,, 49. Ventro-lateral view of *Aspidogaster margaritiferæ*. In this specimen the tube feet were all retracted. The natural size is shown by the small figure on the right.

,, 50. Side view of the same with extended tube feet. The natural size is shown by the small figure on the right.

,, 51. Views of spirit specimens of *Musalia herdmani*, magnified.

,, 52. Transverse section through the suckers and tube feet of *A. margaritiferæ*, highly magnified.

,, 53. Cercaria of *Muttua margaritiferæ* within its cyst capsule. Extracted from the branchial tissue of a pearl oyster. × 30.

,, 54. The same under greater magnification. × 10. Lettering as in fig. 55.

,, 55. The same larva freed from its capsule, and under slight pressure. × 90. *c.s.*, cuticular spines; *e.v.*, excretory vesicle; *d.c.*, digestive cæca; *e.*, eye-spots; *ex.p.*, excretory pore; *p.sh.*, penis sheath; *ph.*, pharynx; *s.v.*, seminal vesicle; *v.s.*, ventral sucker.

,, 56. Penis sheath of same larva.

,, 57. Anterior extremity of same larva. × 240. *c.s.*, cuticular spines; *e.*, eye; *ex.t.*, excretory tubules.

PLATE IV. (4 on Plate).

Fig. 58. *Musalia herdmani*, immature specimen from the mantle of a pearl oyster. Natural appearance fully extended. Letters as in fig. 59.

,, 59. The same shortened and broadened under pressure. Life size on right. *e.v.*, excretory vesicle; *d.c.*, digestive cæca; *ex.p.*, excretory pore; *ex.t.*, excretory trunks; *œ.p.*, œsophageal pouch; *o.s.*, oral sucker; *ov.*, ovary; *ph.*, pharynx; *p.sh.*, penis sheath; *t.*, testis; *v.*, vagina; *v.s.*, ventral sucker.

,, 60. *Aspidogaster margaritiferæ*; adult from the pericardial chamber of a pearl oyster, seen ventro-laterally. The tube feet are retracted. *dig.c.*, digestive cæcum; *ex.t.*, double excretory trunks; *o.s.*, oral sucker; *p.d.*, pedal disc; *ph.*, pharynx; *s.p.*, sucker pits.

Fig. 61. The same seen from the ventral aspect while crawling over a glass plate. The dotted outlines *a* and *b* show the leech-like mobility of the anterior region of the body in attitudes assumed frequently when the worm is restless. *t.f.*, tube feet. The other letters as in fig. 60.

,, 62. View of the posterior extremity of the same, from above, showing the sucker-pits (*s.p.*) closed by the approximation of their lips. The fine transverse wrinkling characteristic of the dorsum of the trunk is also shown in the figure.

,, 63. Ciliated ectoparasite from gills of pearl oyster with paired trilobed eyes.

,, 64. Another characteristic appearance of the same. A contractile vacuole is seen posteriorly and two triradiate eye-spots anteriorly.

,, 65. Diagram of pearl oyster to show at *a* the position of the cyst enclosing *Musalia herdmani*, in the tissues of the pearl oyster. $\times \frac{1}{2}$.

,, 66. A portion of the pedal disc seen when an *Aspidogaster margaritiferæ* is detached from its hold and turned upon its back. The edges of the disc then recurve inwards to varying degrees.

,, 67. Highly magnified view of the end of a proboscis of *Tetrarhynchus minimus*, showing the various sized hooks and their arrangement.

,, 68. Tube feet of *Aspidogaster margaritiferæ* in various states of extension and retraction.

,, 69. *a*, *b*, *c*, successive attitudes assumed by *A. margaritiferæ* during progression. *d*, another view of the same when about to change position.

,, 70. Head of *Tetrarhynchus minimus*.

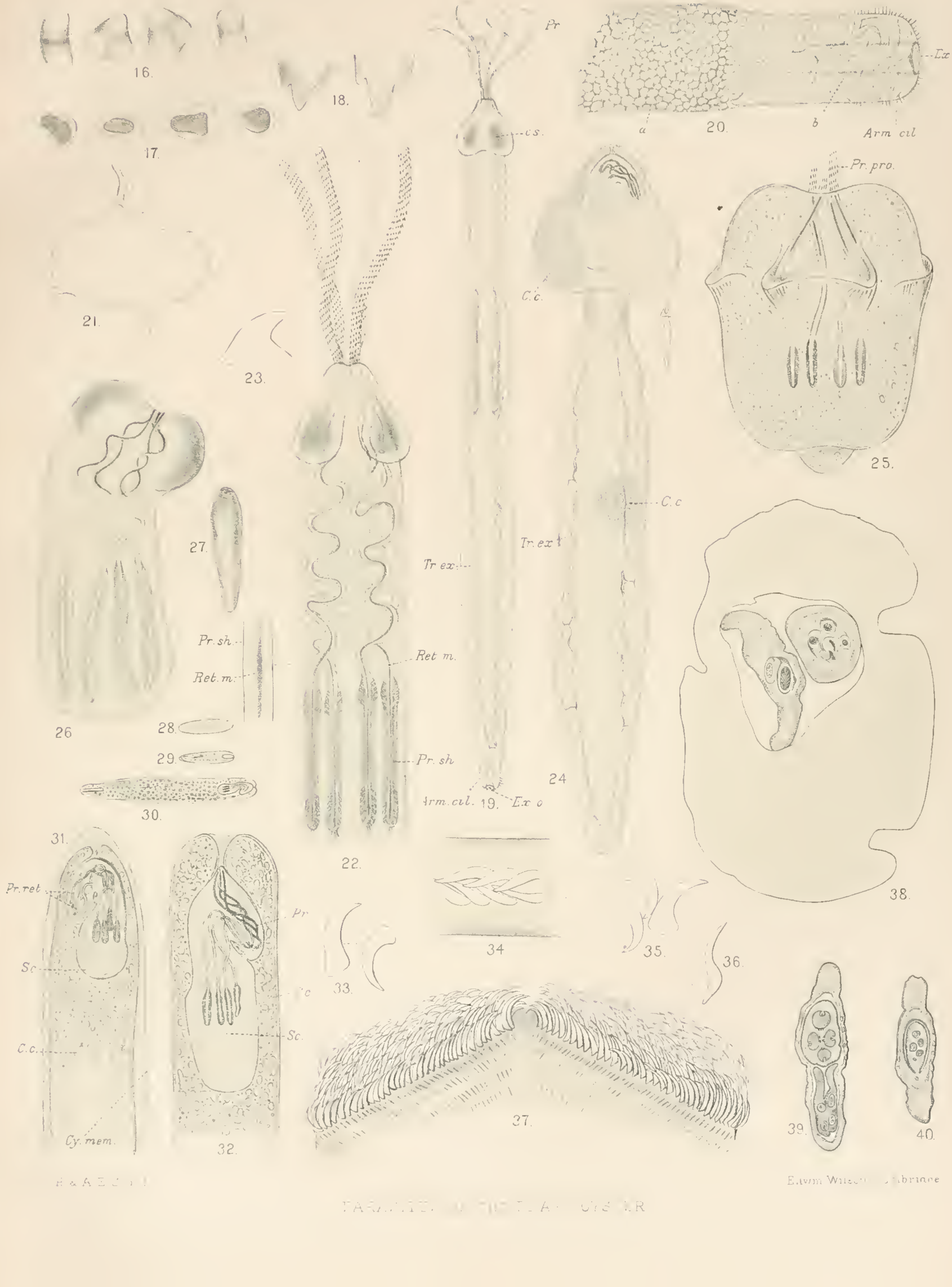
,, 71. Optical section of the same.

,, 72. *Tetrarhynchus minimus*, showing proglottides.

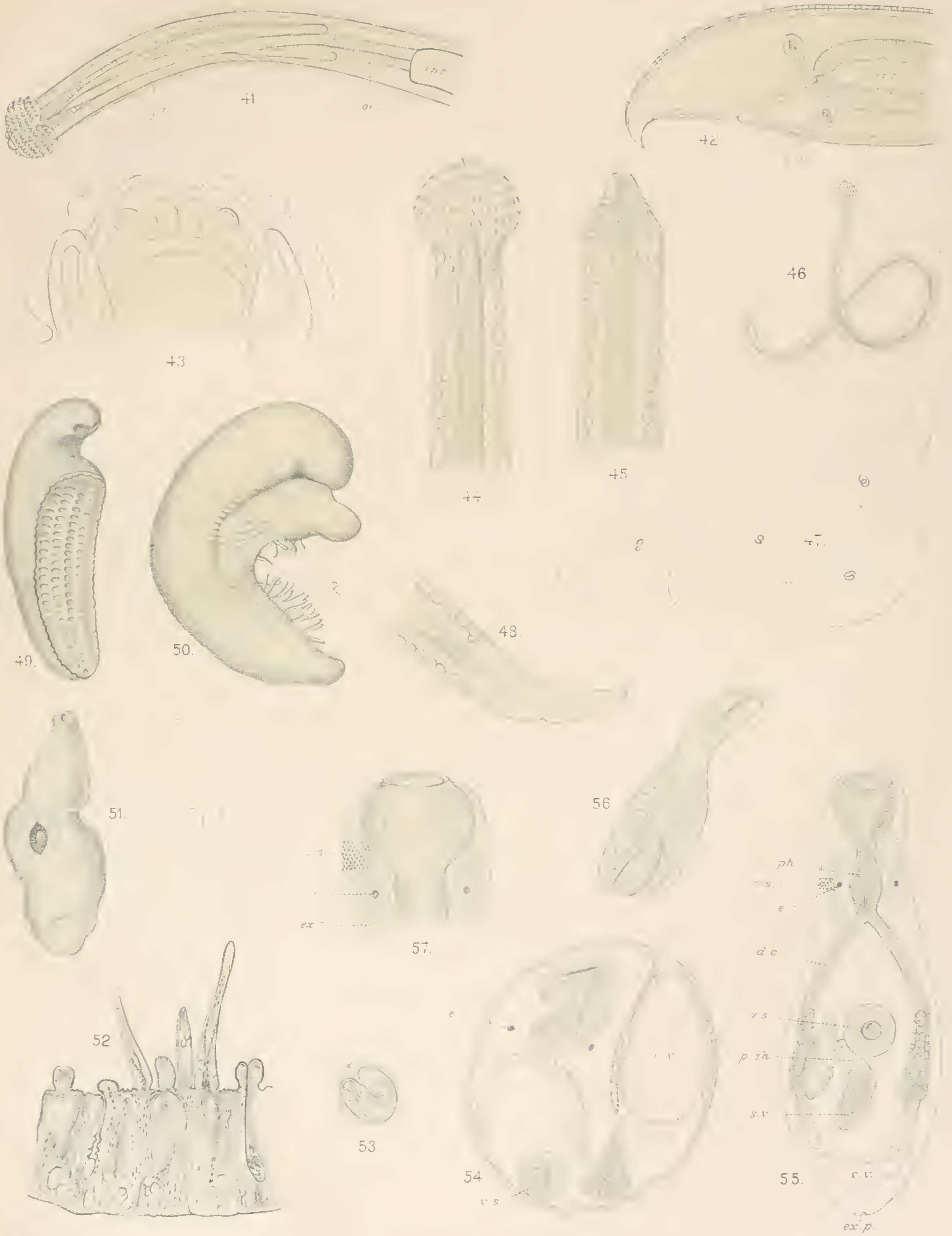
Note.—Owing to an error in the lithographer's office, Plates III. and IV. have been printed as 3 and 4, in Arabic numerals.

J. H. & A. E. S. del.   Edwin Wilson

PARASITES OF THE PEARL OYSTER



PARASITES OF THE PEARL OYSTER



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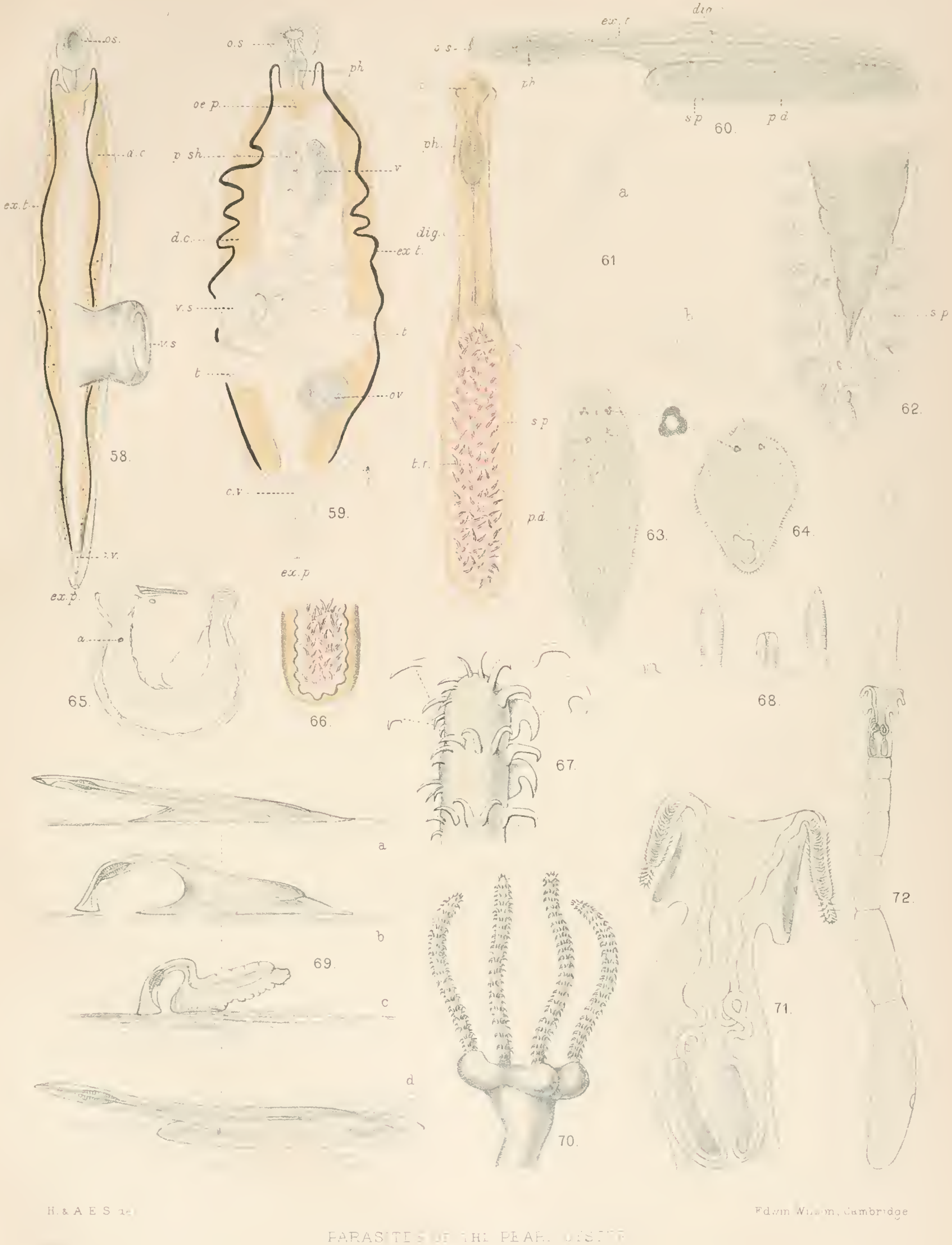
PARASITES OF THE PEARL OYSTER



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PARASITES OF THE PEARL OYSTER

REPORT

ON THE

HYDROIDA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

LAURA R. THORNELY.

[WITH PLATES I. TO III. AND TEXT-FIGURES.]

INTRODUCTORY.

THIS collection of Hydroids from Ceylon comprises 43 species, of which 13 are now described as new to science, and one of these requires the formation of a new genus. A few specimens are too small in quantity to have more than a generic name assigned to them.

Our knowledge of the Hydroid fauna of Indian seas* is mainly due to ARMSTRONG, who described a few species from the Bay of Bengal, two of which are represented in our series; to ALLMAN, who worked out a small collection sent home by Mr. HOLDSWORTH from Ceylon in 1874, containing two of our most striking species; and to HINCKS, who described a small collection made by Dr. JOHN ANDERSON in the Mergui Archipelago in 1889, two species of which we have.

But the faunas of Australia and the East Indies are evidently similar in many of their species, and we have several of those described by BALE and VON LENDENFELD. It is also clear that some of our species have a wide distribution over the globe, as we find in our Ceylon list *Plumularia setacea* and *Cuspidella costata*, both British species, and the former recorded from North America, Australia, and New Zealand, while the latter has been found in North America.

* See List of Literature, p. 125.

Most of the specimens in this collection were dredged by Professor HERDMAN during the cruise of the "Lady Havelock" round Ceylon in February and March, 1902, but some were also obtained by the native divers from the pearl banks, or were picked off the experimental cages in which pearl oysters were kept suspended from the ship.

It is probable that the Ceylon fauna contains many more species of Hydroid Zoophytes, some of which are unknown to science, since there are many small specimens and fragments in the collection which are not large enough or complete enough to be described, but which evidently do not agree with the characters of any known species.

The following is a list of the species described in this Report. Those marked with a star are, I believe, additions to the recorded fauna of the Indian seas :—

ATHECATA.

**Corydendrium chevalense*, n. sp.
Bougainvillia, sp.
**Eudendrium pusillum*, von Lendenfeld.
**Podocoryne denhami*, n. sp.
**Clavactinia gallensis*, n. gen. & sp.
**Tubularia gracilis*, von Lendenfeld.

THECAPHORA.

Halecium, sp.
**H. flexile*, Allman.
**Clytia geniculata*, n. sp.
**Obelia hyalina*, Clarke.
**O. australis*, von Lendenfeld.
O. andersoni, Hincks.
Campanularia juncea, Allman.
**C. corrugata*, n. sp.
**Hebella calcarata* (A. Agassiz).
**Lafoea serrata*, Clarke.
**Cuspidella costata*, Hincks.
**Sertularia gracilis*, Hassall.
**S. ligulata*, n. sp.
**S. fissa*, n. sp.
**S. tenuis*, Bale.
**S. loculosa*, Busk.
**S. rugosissima*, n. sp.
**Diphasia mutulata* (Busk).
Sertularella, sp.
Thuiaria, sp.
**T. palans*, n. sp.
**Desmocyphus palkensis*, n. sp.
**Synthecium orthogonia* (Busk).
Pasythea hexodon, Busk.
Idia pristis, Lamouroux.
**Plumularia setacea*, Ellis.
**P. buskii*, Bale.
**Monostaechas quadridens* (McCrady).
**Antennella gracilis*, Allman.
A. allmani, Armstrong.
**Aglaophenia perforata*, Allman.
**A. phœnicea*, Busk.
Halicornaria insignis, Allman.
H. setosa, Armstrong.
**Lytocarpus hornelli*, n. sp.
**L. fasciculatus*, n. sp.
**L. plumosus*, n. sp.

This list shows in all thirty-two species added to the list for the Indian seas in addition to seven previously known and four left specifically undetermined.

HYDROIDA.

Sub-order I.: ATHECATA.

Family: TURRIDÆ.

Corydendrium chevalense, n. sp.—Plate I., fig. 4.

Trophosome.—Colony reaching the height of $\frac{1}{2}$ an inch, with a simple or branched stem of a pale straw colour, slightly wrinkled, but never ringed. Branches lying alongside the stem for a short distance near their origin, then diverging; very much twisted and entangled (see Plate I., fig. 4). Hydranths varying in size, those on unbranched stems the largest, with about 18 tentacles scattered on the upper $\frac{2}{3}$ of their length.

Gonosome.—Medusiform gonophores on short peduncles, springing singly or 2 or 3 near one another, often 2 opposite, on both sides of the stem, between the origin of the branches and the hydranth.

Locality:—On *Pecten* shells and on sea-weeds from the Cheval Paar, Gulf of Manaar, 6 to 8 fathoms.

From indications in the gonophores, which vary much in their stages of development on the same specimen, the manubrium appears to be four-lipped, the radiating canals four, and the tentacles many. The form of the medusa of *Corydendrium* has not yet been traced, and the one species, *C. parasiticum*, Cavolini, has now remained so long imperfectly known that it seems doubtful whether its description will ever be completed. In the meantime it seems better to place the present species here rather than to form a new genus or to place it with *Turris*, only known as an unbranched form.

The fully developed trophosome of *Turris* has, however, not yet been seen. If, therefore, the further development of the present gonophores should lead to their identification with those of *Turris*, as appears possible, then this species will require to be transferred to that genus, the definition of which will be altered so as to include simple *or branched* forms.

Family: BOUGAINVILLIDÆ.

Bougainvillia, sp.

This is not recognisable as any known species, and there is not sufficient material to enable me to describe it fully as a new species. One peculiarity of the form is that the branches have frequently blunt-ended tendrils growing from them.

Locality:—Found growing among colonies of a Campanularian (*Obelia australis*) from the Cheval Paar, Gulf of Manaar, 6 to 8 fathoms.

Family: EUDENDRIIDÆ.

Eudendrium pusillum, von Lendenfeld (17).—Plate I., fig. 5.

From their mode of growth, smooth stems and the colour of the zooids, and also from the position of the gonophores, I believe the present Ceylon specimens to belong to this species. Many of the colonies are only half an inch in height, but some are larger than has yet been described for *E. pusillum*, reaching $1\frac{1}{4}$ inches. The main stem is of a very dark brown, annulated at its origin and with a few rings occurring here and there, up the stem. The branches are alternate, ringed above their origin, and the ramuli which terminate in hydranths bearing gonophores are ringed or wrinkled throughout. These last are not so long as the ordinary ramuli, their hydranths never lose all the tentacles, although they become atrophied. There are only female gonophores present. The hydranths have about 26 tentacles each. As this species has not been figured before, I show it on Plate I., fig. 5.

Locality:—This species, previously known from Port Jackson, Australia, occurred on the experimental pearl-oyster cages hung over the side of the ship at Cheval Paar, in the Gulf of Manaar, in April, 1902.

Family: HYDRACTINIIDÆ.

Podocoryne denhami, n. sp.—Plate I., fig. 6.

Trophosome.—Basal crust beset with numerous tall, stout, linear, reddish spines. Hydranths white, with about 24 tentacles on the barren ones and only 4 or 5 on those bearing gonophores, and these latter are also considerably smaller.

Gonosome.—A pair of large and globose gonophores to each hydranth.

Locality:—Growing on a *Murex* shell containing a Pagurid dredged in Palk Strait.

This species resembles *Podocoryne areolata* (Alder) in general appearance of the hydranths, the spines and the gonophores, as figured by Hincks, but the tentacles are far more numerous on the larger hydranths of the colony, and the gonophores when separated from the colony are found to be borne on hydranths in place of being sessile on the common base, as at first sight they appear to be.

At Professor Herdman's suggestion, this interesting new species from the north of Ceylon is named in honour of Mr. E. B. Denham, C.C.S., Assistant Government Agent in the Manaar district, near where the specimen was obtained.

Clavactinia, n. gen.

Trophosome.—Hydranths claviform, sessile, with filiform tentacles forming several verticils below the base of a conical proboscis; borne on an expanded crust.

Gonosome.—Sporosacs borne on blastostyles which rise directly from the crust between the hydranths.

This genus differs from *Hydractinia* in having several verticils of tentacles (see Plate I., fig. 3), and in not having globular clusters of thread-cells in place of tentacles on the blastostyle.

Clavactinia gallensis, n. sp.—Plate I., fig. 3.

Trophosome.—Colonies an inch square, or more, having a yellowish crust spotted with minute dark red spines, and with larger ridged spines of the same colour placed at intervals. Hydranths opaque white with about 14 tentacles surrounding the upper portion of the body.

Gonosome.—Sporosacs borne on very short-stemmed blastostyles, 5 or 6 on each, almost round in shape and showing about 5 divisions.

Locality:—Growing on gastropod shells belonging to *Eburna* and *Neritina;* dredged in Galle Bay, 2 fathoms.

There are no spiral zooids on these colonies, which have, with their spinous crusts, so much the appearance of a *Hydractinia.* The blastostyles are very short, and the sporosacs on them are in various stages of development. The *Eburna* shells are covered with the colonies, many of them not fully grown; these shells contained the living animal at the time they were taken. On the *Neritina* shell the hydranths and gonophores cover the crust much more fully, but the hydranths are smaller and have their tentacles so contracted as to appear almost capitate.

Family: TUBULARIIDÆ.

Tubularia gracilis, von Lendenfeld (17).

From the general resemblance and the large number of gonophores, borne on erect peduncles, I am inclined to consider that the present specimens belong to this Australian species, although when more material is at hand for examination, further details may appear which will require their separation as a distinct form. The stems are unbranched, entangled with others at their bases by their rhizomes. They are smooth, like von Lendenfeld's specimens of *T. gracilis*, for the most part, but are occasionally ringed at the base and here and there up the stem. The largest are only $\frac{3}{4}$ of an inch in height, but as the zooids vary a good deal in general size, the stems may possibly grow to the usual height of *T. gracilis* under favourable circumstances. The hydranths are slightly smaller than those of *T. gracilis*, the largest present being only about $\frac{2}{10}$ of an inch across the tentacles and $\frac{1}{10}$ of an inch in total height. They are reddish in colour when living, and the gonophores are greenish-yellow. The gonophores are borne on short, branched peduncles, and are present in various stages of development. The most fully developed have 4 lobes, and show a division of their sides by 4 longitudinal grooves. A hydranth carries about 9 peduncles with about 30 gonophores on each.

Locality:—This species, previously known only from Port Jackson, Australia, was found growing on the fibre of the "coir" baskets containing experimental pearl oysters suspended from a buoy in Galle Bay during June, 1902.

Sub-order II.: THECAPHORA.

Family: HALECIIDÆ.

Halecium, sp.

There are only a few fragments of this interesting looking species with very widely expanded hydrothecæ. It looks somewhat like *Diplocyathus*, Allman (4), but is without the nematophore-like cup characteristic of that genus.

Locality:—North of Cheval Paar, 7 to 10 fathoms.

Halecium flexile, Allman (4).

Several young colonies, only $\frac{1}{2}$ an inch in height, were found growing on the oyster cages suspended from the side of the ship at Cheval Paar, in the Gulf of Manaar.

These colonies may seem too small to be referred to this species with certainty, but they are evidently young, only here and there show the beginning of a fascicled stem and have no gonophores present. The hydranths are very large and very much swollen below the base of the tentacles. The specimens are beautifully preserved, showing the details of internal structure clearly. The hydrophores do not stand away from the internode so much as is shown in Allman's figures, but the shallow annulation of the internodes is the same.

Locality:—This species was previously recorded from near Marion Island and from Patagonia; and the present specimens were found on oyster cages at the Cheval Paar, in the Gulf of Manaar.

Family: CAMPANULARIIDÆ.

Clytia geniculata, n. sp.—Plate III., figs. 4, 4a.

Trophosome.—Colony $\frac{3}{5}$ of an inch in height. Stem bending slightly to right and left, a hydrotheca on a ringed pedicel at each flexure, which has a decided knee-like bend (Plate III., fig. 4). Stem monosiphonic, branched sparingly, a branch either taking the place of a hydrotheca or being given off from the hydrothecal pedicel near its base. Hydrothecæ on long or short pedicels, ringed throughout, or only above and below, with from 5 to 20 rings; large and deep (fig. 4), with long 2-spined teeth, and very compressible.

Gonosome.—Gonothecæ cylindrical above, narrowing rapidly downwards, on short, ringed stalks (fig. 4a), about 5 rings, and with a very short neck and wide rim to the aperture, situated near the base of the pedicels of the hydrothecæ and containing medusoid gonophores, the most advanced of which show 4 rudimentary tentacles.

Locality:—Growing on oyster cages suspended over the side of the ship, between February 15 and March 10, on the north-east Cheval Paar, Gulf of Manaar.

The peculiar mode of branching is the most striking feature of this form (Plate III., fig. 4), one pedicel bearing a hydrotheca gives off another from its side which starts

with a knee-like bend and then runs up almost parallel with the first; another is given off from this one again on the opposite side from the first, and so on alternately, sometimes for nine times in succession, with no other form of branching. A more complicated form of growth is seen when two branches are given off almost opposite each other, or when the branches divide again.

The sides of the hydrotheca are so compressible that the form of the teeth, in these preserved specimens, cannot be seen satisfactorily. They are folded over as in BALE's figure of *Campanularia bispinosa* (12), and so are probably arranged in pairs as in that species.

Obelia hyalina, CLARKE (13).

A few fragments, probably of this form, previously found north of Goblos Island, were found growing on oyster cages hung from the ship, between February 15 and March 10, on the north-east of the Cheval Paar.

Obelia australis, VON LENDENFELD (17).

A few fragments of this form, previously found in New Zealand, were growing on oyster cages hung from the ship, between February 15 and March 10, on the north-east of the Cheval Paar.

Obelia andersoni, HINCKS (14).

These specimens have rather more rings on the pedicels of the hydrothecæ and teeth on the hydrotheca margin than HINCKS gives. He does not mention the height of the colonies, nor whether they are branched. Our specimens are $\frac{1}{4}$ of an inch in height, and they branch occasionally, in which case there is always a hydrotheca in the axil. The shape of the hydrothecæ, which HINCKS lays most stress on in his diagnosis of the species, corresponds with these specimens. The line represented in HINCKS' figures running round the hydrotheca, near the base, is only to indicate the beginning of the cylindrical portion, I believe; it is not visible in our specimens. This is a most delicately beautiful little species.

Locality:—Previously known from the Mergui Archipelago, it now occurs growing on oyster cages hung over from the ship, between February 15 and March 10, on the north-east Cheval Paar.

Campanularia juncea, ALLMAN (1).—Plate I., figs. 1 to 1B.

The specimens of this form in the present collection agree with ALLMAN's description for the most part, but our colonies reach a height of 18 inches instead of only 12, while gonothecæ are present, and in some cases an operculum on the hydrotheca—both structures previously unknown. Moreover, our colonies do not show the division of the stem into internodes which ALLMAN describes and figures. Still, this is such a striking form that there can be no doubt about the identification.

There are two kinds of gonothecæ borne on separate colonies, which are thus of

distinct sexes. They are placed beneath hydrothecæ on the stems and branches, and turn downwards at about the same angle that the hydrothecæ stand upwards. The male gonotheca (Plate I., fig. 1) is cylindrical, with a wrinkled outline and rounded top, about $\frac{1}{3}$ as long again as the hydrotheca; while the female (Plate I., fig. 1A) is truncated above, with a marginal rim and a boss to one side of the upper surface, and is broader and not so long as the first. They both have the same coarse, granular texture as the hydrothecæ.

Fig. 1. *Campanularia juncea*—showing expanded zooid, and hydrotheca with operculum. Magnified.

In a few specimens of about 2 inches in height, the details of the zooid (text-fig. 1), its 34 tentacles, its base resting on a floor above the base of the hydrotheca, &c., are quite visible, and in these can be seen distinct opercula with 4 valves (Plate I., fig. 1B). A trace here and there of what may be broken portions are the only indications of the operculum in the rest of the material, which is composed of larger colonies (text-figs. 2, 3), opaque and older looking in comparison with these small fresh bits. If the specimens with opercula are not to be regarded as a different species from those without, which I have not the least inclination to believe, then the genus *Thyroscyphus*, ALLMAN (**3**), founded for species having a 4-valved operculum, must either be given up or the present species must be removed to that genus. I prefer the former course; and it seems probable that the opercula are only present in the young condition and become lost in older colonies.

For a Campanularian this is a remarkable species on account of its great size and coarse habit, and its marked resemblance to a Sertularian (text-figs. 2, 3). It grows in great profusion over some parts of the pearl banks, and is said to be characteristic of the East Cheval Paar, where, in the Inspector's reports, the great masses sometimes brought up by the divers are alluded to as "heather." Text-fig. 2 shows the species in the fresh living state, and fig. 3 shows older coarser tufts, largely dead, such as form the "heather" of the diver.

Locality:—Generally distributed round the coast of Ceylon, but especially large and abundant on some parts of the pearl banks in the Gulf of Manaar.

Campanularia corrugata, n. sp.—Plate I., fig. 2.

TROPHOSOME.—Stems of varying length rise from a creeping stolon, both being thick and wrinkled, but without rings. Hydrothecæ about $\frac{1}{10}$ of an inch in height usually, but varying in size with age; cylindrical, the same width all their length; transversely ringed more or less, sometimes with as many as 8 rings; the aperture

obliquely sloped with an everted even rim which is often reduplicated, while sometimes a complete new hydrotheca rises out of the old one, its stem passing through this, and standing at varying heights above it (Plate I., fig. 2). Zooid with about 20 tentacles. Gonosome not present.

Locality :—Found creeping over shells and zoophytes, north of Cheval Paar, 7 to 10 fathoms.

This species has very much the appearance of *Campanularia grandis*, ALLMAN (1),

Fig. 2. *Campanularia juncea*—well-grown but living. This and fig. 3 are about $\frac{1}{3}$ natural size.

Fig. 3. *Campanularia juncea*—old coarse tufts ("heather"), mostly dead.

but has no node below the hydrotheca, although there are sometimes one or two joints, and it does not narrow towards the margin. It has apparently a tendency to completely reduplicate itself, a habit I have only seen described in the case of *Clytia poterium*, L. AG. (8). The older hydrotheca has always lost its zooid when this happens, and also its corrugated sides, and looks old and worn.

Hebella calcarata (A. Agassiz) (9).

This species, previously known from Woods Holl, on the east coast of North America, was found creeping over Sertularians from the Gulf of Manaar.

Family: LAFOËIDÆ.

Lafoea serrata, Clarke (13).

A few colonies of this delicate little form were found creeping over Sertularians from the Gulf of Manaar. Previously known from Cuba.

Cuspidella costata, Hincks (15).

One or two broken fragments of this distinctive form were found creeping over a Sertularian from the Gulf of Manaar. The species was previously known from both sides of the North Atlantic—Woods Holl and Britain.

Family: SERTULARIIDÆ.

Sertularia gracilis, Hassall—Plate II., fig. 3.

Our Ceylon specimens correspond with Hincks' (15) description of this form in all its parts, but are much more attenuated than his figures represent, both in stem and hydrotheca, so that they have quite a different appearance (see Plate II., fig. 3). Many of the hydrothecæ have reduplicated margins, which adds length to them; also in the preserved specimens the operculum often stands open and adds further to the appearance of length. The species is known from both shores of the North Atlantic (Britain and North America).

Locality:—Galle and onwards up the West Coast of Ceylon, deep water; attached to Algæ, &c.

Sertularia ligulata, n. sp.—Plate II., figs. 1 to 1B.

Trophosome.—Colony about $1\frac{1}{4}$ inches in height in the largest specimens, with simple or sparingly branched stems. Branches mostly given off from one side of the stem, either two or three near together, or widely separated and few (Plate II., fig. 1). They are narrowest at their junction with the stem below a pair of hydrothecæ, are smooth near the base, and have an oblique joint below their lowest pair of hydrothecæ (Plate II., fig. 1A). Both stem and branches usually end in tendrils terminated by large flat disks which adhere to foreign objects (fig. 1A).

Hydrothecæ always in opposite pairs, one pair to an internode. They touch each other for $\frac{2}{3}$ of their length in front and are widely separated behind; the free portion is abruptly divergent, so as to leave a fold across the front of the cell; orifice bilabiate.

A good length of internode is seen below the hydrothecæ, and, usually, a joint just above a pair of hydrothecæ. A peculiar process like a little tongue or strap (hence the name I give this species) protrudes from the orifice above the zooid, and is sometimes contracted within the hydrotheca (fig. 1A).

GONOSOME.—Gonothecæ resemble closely those of *Sertularia complexa*, CLARKE (13), barrel-shaped and rugose, borne on the stems singly below hydrothecæ (fig. 1B).

Locality :—Found growing on stems of other Hydroids and on the experimental oyster cages in the Gulf of Manaar.

I have seen no account or figure of anything corresponding with the peculiar tongue-like process described above, except in HINCKS' description (16) of the contents of the nematophores of some Plumularians. In *Diplocyathus*, ALLMAN (4), and *Hypophyxis*, ALLMAN (4), we have other forms of Hydroids outside the Plumulariidæ which show nematophores, but in the present species there is no containing receptacle for this process apart from the hydrotheca itself. The process appears to reach from the centre of the stem and proceeds along the upper bent portion of the hydrotheca.

The orifice of this species is bilabiate, the upper surface slightly peaked, but when the operculum is open it often appears to be even-rimmed and hooded.

Sertularia fissa, n. sp.—Plate II., figs. 2 to 2F.

TROPHOSOME.—Colony a tangled mass of loose, straggling, rather coarse, brown stems, about 3 inches in height, dichotomously branched (Plate II., fig. 2); both stem and branches bearing hydrothecæ, in opposite pairs widely separated from one another (figs. 2D and 2F). Branches given off from before and behind a pair of hydrothecæ, not from their sides; occasionally two branches coalesce, and there are two pairs of hydrothecæ found back to back (see figs. 2D, E, F). Hydrothecæ adherent for $\frac{2}{3}$ of their length, free above, and diverging at right angles with the stem. They touch each other in front (fig. 2A), on the upper pairs, on the branches; but are separated below, and are widely apart at the back (fig. 2B). Margin with an upper and 2 lateral teeth, often reduplicated, and having an operculum.

GONOSOME.—Gonothecæ borne on stem and branches, attached just below a hydrotheca (fig. 2C) by a short pedicel, and turned abruptly up to lie along the branches. They are about 3 times the length of the hydrothecæ, oval, with a short, broad neck and even rim, and strongly ribbed.

Locality :—Found on worm tubes from off Galle, off Mount Lavinia, off Kaltura, and on the Cheval Paar, depths of from 6 to 30 fathoms.

Sertularia tenuis, BALE (11).—Plate II., fig. 5.

The present specimens agree with BALE's figures and description of the unbranched form of *Sertularia tenuis* in size and shape of the hydrothecæ—there are no gonothecæ. These colonies show the margin of the hydrothecæ often reduplicated, and there is a bivalved operculum. There is one colony which may be mentioned as possibly only an abnormality in this species. It has a branch which proceeds from one of a pair of the hydrothecæ of the stem (see fig. 5), a feature of the genus *Thecocladium*,

ALLMAN (2), with which genus, however, this species has nothing else in common. The species is known from Williamstown, Australia.

Locality :—The Ceylon specimens were attached to worm tubes, shells, algæ, &c., from the Cheval Paar, Gulf of Manaar.

Sertularia loculosa, BUSK (10).

These specimens correspond with the description of the unbranched form in BALE'S catalogue, they are rather shorter and have no gonothecæ present.

Locality :—This species, previously known from Australia, was found north of the Cheval Paar, 7 to 10 fathoms, growing on the calcareous alga *Halimeda.*

Sertularia rugosissima, n. sp.—Plate II., fig. 4.

Stems simple, rather less than $\frac{1}{2}$ an inch in height, of a bright brown colour. Hydrothecæ, one pair to an internode, corrugated for the upper $\frac{3}{4}$ of their length (fig. 4). They touch in front, excepting the lower ones on the stem, and are separated behind, and are free and divergent at right angles for $\frac{1}{2}$ their length. They have two lateral teeth and are closed by a bivalve operculum.

Gonosome not present.

This is a neat, minute form, quite half as small as *Sertularia pumila,* and is the only Sertularian with opposite annulated hydrothecæ.

Locality :—Found creeping over algæ from the Gulf of Manaar.

Diphasia mutulata (BUSK), (10).—Plate II., figs. 6 to 6B.

This form corresponds entirely with BUSK'S descriptions. The pieces are only about an inch in height, and are unbranched and bear male gonothecæ (Plate II., fig. 6). On some specimens the hydrothecæ are smaller and less prominent than on others, and sometimes subalternate (fig. 6B), and the gonothecæ on these have only a few spines near the top and are of smaller size. This form is shown on Plate II., fig. 6A. The species has been found at Torres Strait and Port Molle, Australia.

Locality :—Our specimens were growing on stems of *Lytocarpus,* &c., at several localities : off Galle ; Station I., off Negombo ; and in the Gulf of Manaar.

Sertularella, sp.

A fragment of a *Sertularella* was found on the Cheval Paar, Gulf of Manaar.

Thuiaria, sp.

TROPHOSOME.—Stems branched, about $\frac{3}{4}$ of an inch in height, not fascicled, having two, alternate, hydrothecæ to an internode on the unbranched portion of the stem, and where there is a branch, one hydrotheca is present also in its axil. Branches alternate, with a joint shortly above their origin.

Hydrothecæ alternate, well separated, except near the tops of branches, where they

slightly overlap one another, and are more oval in shape. Margin with two teeth. No gonothecæ present.

There is such a small piece of this, that although the characters do not agree with those of any known species of *Thuiaria*, still I do not feel justified in describing it as a new form.

Locality :—Gulf of Manaar.

Thuiaria palans, n. sp.—Plate III., figs. 5, 5A.

TROPHOSOME.—Stem of a bright brown colour, branched, with a joint just below the origin of each branch. Branches alternate, long and straggling. Hydrothecæ two or three to an internode on the stem, four or five on the branches, adherent up to quite near the top, when they become free and divergent; margins reduplicated and with two lateral teeth.

There is only one broken piece of this form $2\frac{1}{2}$ inches in height, but it seems so distinct from all previously described species that I feel bound to describe it as new, and I believe the above characters will determine it.

Locality :—Palk Bay, 7 fathoms.

Desmocyphus palkensis, n. sp.—Plate II., figs. 7 to 7B.

TROPHOSOME.—Hydrocaulus $2\frac{1}{2}$ inches in height, with a dark brown stem, pinnately branched; the pinnæ paler in colour, alternate, one to an internode, with a straight and an oblique joint shortly above their point of origin.

Hydrothecæ alternate on the stem and separated from each other by its width (Plate II., fig. 7), adnate for $\frac{2}{3}$ of their length, one in the axil of each pinna and one on either side of the internode above; on the pinnæ they are opposite, a pair to each internode (fig. 7A), adnate for $\frac{2}{3}$ of their length in front, free and divergent above, with two lateral teeth and an operculum.

GONOSOME.—Gonothecæ borne on short stems below the hydrothecæ on the stem, oval, strongly ringed, with a wide neck (fig. 7B).

Locality :—Palk Bay, 7 fathoms.

These specimens are broken off above and below, but have the appearance of being nearly complete. They resemble *Desmocyphus longitheca*, ALLMAN (**3**), in some respects, but the hydrothecæ on the stem are never opposite and adnate to one another and the specimens are $1\frac{1}{2}$ inches taller.

Synthecium orthogonia (BUSK) (**10**).

A few of the hydrothecæ on these specimens are subalternate.

Locality :—The species is known from Port Jackson. Our Ceylon specimens were found on the experimental oyster cages on the Cheval Paar, Gulf of Manaar.

Pasythea hexodon, Busk (10).

There are some unbranched colonies of this species with from four to ten hydrothecæ in a set, and with one or two gonothecæ.

The species is known from Australia. Our specimens were found growing on stems of *Halicornaria insignis*, &c., on the north of Cheval Paar, Gulf of Manaar.

FAMILY: IDIIDÆ.

Idia pristis, Lamouroux.

The largest piece of these specimens is broken off at the top, and is $3\frac{1}{2}$ inches in height. Gonothecæ are present.

This species is known from Torres Strait, Bahia, and the Persian Gulf. Our Ceylon specimens were on worm tubes, &c., from off Galle, and onwards up the west coast to Mount Lavinia and Kaltura, and also in the Gulf of Manaar.

FAMILY: PLUMULARIIDÆ.

Plumularia setacea, Ellis.

A good many colonies of this species were found, and gonothecæ are present.

It was previously known from Australia, Messina, North America, and Britain.

Locality:—Our Ceylon specimens were attached to worm tubes, &c., from the north end of Cheval Paar, 7 to 10 fathoms, and elsewhere in the Gulf of Manaar.

Plumularia buskii, Bale (11).

There are a few colonies only of this form, about 1 inch in height, and without gonothecæ, but otherwise following Bale's description, excepting that, in some cases, a few of the lower pinnæ on the stems are opposite instead of alternate, an arrangement that has been described in the case of *Plumularia cornucopia*, Hincks (16).

The species is only known from Australia. Our Ceylon specimens were found in the Gulf of Manaar.

Monostæchas quadridens (McCrady) (18).

The specimens of this form are about the size of those first described when Allman founded the genus; half an inch is the height of the largest colony.

The species is known from Pacific reef, Barbadoes, and the North Atlantic.

Locality:—North of Cheval Paar, 7 to 10 fathoms, Gulf of Manaar.

Antennella gracilis, Allman (3).

These specimens agree with the description of *Antennella gracilis* in all respects but size, and are probably from their position young colonies. They are about $\frac{1}{4}$ inch instead of 1 inch in height. In the details of stems, hydrothecæ and nematophores they agree. The hydrothecæ are not quite cylindrical, narrowing downwards slightly.

There are a few gonothecæ, which is important, as these have not been observed before in the genus *Antennella*. They are identical in position and shape with those of *Monostæchas quadridens*, ALLMAN (3), and have the two nematophores at their base. These colonies resemble the branches of *M. quadridens* exactly, but are on a smaller scale.

This species was known previously only from the West Indies, between Cuba and Florida. Our Ceylon specimens were found growing on the experimental oyster cages on the Cheval Paar, Gulf of Manaar.

Antennella allmani, ARMSTRONG (7).

There is very little of this form. The lateral nematophores are very long, and the hydrothecæ have everted rims, as figured by ARMSTRONG (7).

This is an Indian Ocean species which was dredged off Galle and onwards up the west coast of Ceylon.

Aglaophenia perforata, ALLMAN (2).

In the absence of corbulæ, I cannot be quite sure of the identity of this species, of which a quantity was found growing over Amphipod tubes. It differs from ALLMAN'S description in being rather larger, colonies reaching the height of half instead of only quarter of an inch, and in the number of marginal teeth on the hydrothecæ not exceeding ten. There is a nematophore at the base of each pinna and one below, on the same internode of the stem as the pinna, which is not described by ALLMAN. ALLMAN'S specimens were from the St. Vincent Islands. The Ceylon specimens were found growing on masses of Amphipod tubes and on small pearl oysters in the experimental oyster cages in the Gulf of Manaar.

Aglaophenia phœnicea, BUSK (10).

There are a few colonies of this form growing over worm tubes from the north end of the Cheval Paar, 7 to 10 fathoms. It was previously known only from Torres Strait.

Halicornaria insignis, ALLMAN (1)—(Text-fig. 4).

The species described under this name by ALLMAN was 9 inches in height, unbranched, with a stout, monosiphonic stem, of a dark brown colour; the hydrocladia paler in colour; two, opposite, hydrocladia to an internode; hydrothecæ winged and toothed, with a long, curved, mesial nematophore, and two lateral nematophores taller than the hydrothecæ.

The present specimens correspond exactly with this description, but that the colonies are of far greater height, one reaching a size of $15\frac{1}{4}$ inches, spreading from the base in a beautiful fern-like way (see text-fig. 4), and that they are covered with gonothecæ.

There is also one colony of about 9 inches in height, exactly corresponding with

ALLMAN's description, except for the addition of the gonothecæ. This colony and the larger colonies evidently belong to the same species, so that I do not hesitate to call

Fig. 4. *Halicornaria insignis.* About ¼ natural size.

them all *Halicornaria insignis*, and to add the description of the gonosome, previously unknown.

The gonothecæ resemble those of *H. bipinnata*, ALLMAN (1). They are of the same colour as the hydrothecæ, obconic in form, one side more convex than the other, truncated above, and attached below, by a short stem, to the hydrocladia below its lowest hydrotheca. As the hydrocladia are opposite and closely set, the gonothecæ form a thick double row up the stems.

There are some specimens of the little bivalve mollusc *Avicula* (*Margaritifera*) *zebra*, REEVE, attached to these colonies, and so coloured and banded as to present the appearance of being part of the Zoophyte.

Locality :—Pearl banks, Gulf of Manaar.

Halicornaria setosa, ARMSTRONG (7).

The specimen from off Kaltura differs from the others very much in appearance, owing to the pinnæ being less fasciculated and twice as long, but this does not seem a sufficient reason for making a new species, unless, when more material has been examined, other special characteristics are found.

Locality :—Off Mount Lavinia and Kaltura, and on the Cheval Paar, Gulf of Manaar.

Lytocarpus (?) hornelli, n. sp.—Plate III., figs. 1 to 1B.

TROPHOSOME.—Colony slender, 16 inches to 18 inches in height, with long, straggling branched stems (fig. 1). Stem and branches polysiphonic, of the same thickness, and dark brown colour. Branches alternate usually, but occasionally several given off near together and from one side of a stem. Branchlets carrying hydrocladia about $\frac{1}{10}$ of an inch in length, arranged in loose, bottle-brush form on the branches, having monosiphonic stems, an oblique joint some little way from their bases, and, below that, transverse joints which make long and short internodes to the base.

Cauline nematophores form a line up the central fascicle of the main stem and branches.

Hydrocladia are of a pale straw colour, not closely set; they branch alternately from the upper side of the branchlets, one from each internode, and there is one nematophore on each internode above this which is long and tubular and bends in the opposite direction to the hydrocladia.

Near the base of each hydrocladia there is a solitary nematophore; then follow hydrothecæ, closely set, separated by transverse joints. They are beautifully transparent and elegant, with an even, outwardly curved rim, and are about twice as deep as they are wide, having no anterior fold (fig. 1A).

The mesial nematophore reaches about halfway up the hydrotheca, is adnate below, tubular and diverging outwards above, with two orifices. The lateral nematophores are tubular, adnate to the hydrotheca below its rim and rising about as much above it. The intrathecal ridge is very near the base of the hydrotheca and reaches more than halfway across it.

Between each branchlet on the upper portion of the stem is a string of nematophores in threes, sometimes as many as twelve sets in a line (fig. 1B).

Gonosome not present.

Locality:—Off Mount Lavinia and Kaltura; also Station I., off Negombo.

Lytocarpus fasciculatus, n. sp.—Plate III., figs. 3 to 3B.

TROPHOSOME.—Colony, stems fascicled, thick, of a pale brown colour; giving off, at intervals of about an inch, alternate branches, less thick, but fascicled like the stem, and of the same colour (fig. 3). These are about $2\frac{3}{4}$ inches in length, and carry closely set hydrocladia, about $\frac{6}{10}$ of an inch long, of a paler colour than the stems, branching alternately and pointing forwards and outwards, with a short cauline nematophore between each.

Hydrothecæ (fig. 3A) closely set, deep, with a crenate margin and a central tooth, the sides sloping upwards from the tooth, and backwards, and being free from the stem for a short distance from the top. Mesial nematophore short, barely half as long as the hydrotheca, free and spout-like for a third of its length. Lateral nematophores short and broad, not reaching to the top of the hydrotheca.

Intrathecal ridge very low down, reaching about half-way across the hydrotheca.

Phylactocarps (fig. 3B) of the same length as the hydrocladia, occurring at intervals up the branches among these, a hydrotheca at the base, succeeding internodes being alternately barren or with a spine which has a large flattened gonotheca at its base. The spines all turn to the same side.

Locality :—Off Galle and onwards up the west coast to Kaltura and Mount Lavinia.

There are only pieces broken from the tops of colonies of this form, and they appear to belong to a large species. In some respects they resemble *Lytocarpus secundus*, but the branches are not so closely set on the stems and have not such a one-sided mode of growth, and are about $\frac{1}{2}$ an inch longer, $\frac{6}{10}$ of an inch instead of $\frac{2}{10}$. Also the phylactocarps in *L. secundus* are only half as long as the hydrocladia, while here they are as long, and the hydrotheca at their base is not described as being present in *L. secundus*.

Lytocarpus plumosus, n. sp.—Plate III., figs. 2 to 2B.

Trophosome.—Colony about 2 inches in height, unbranched, plumose (fig. 2); the stem monosiphonic, of a dark brown colour. Hydrocladia closely set, $\frac{4}{10}$ of an inch in length, pale yellow, given off alternately to right and left from the front of the stems, one to each internode, which carries besides two cauline nematophores, one at the base of the hydrocladia and one below it. Hydrothecæ (fig. 2A) fairly deep, narrowing downwards from the rim, which is toothed, one small tooth in front and two on either side. Mesial nematophores about the height of the hydrothecæ, free and spout-like near the top. Intrathecal ridge sloping upwards, from low down posteriorly to about opposite the middle of the nematophore.

Phylactocarps (fig. 2B) scattered up the stems, about half as long as the hydrocladia. They have one hydrotheca at the base of each and spines, branching to either side alternately, above it.

Gonosome.—Gonothecæ at the bases of the spines, one to each.

Locality :—Growing on worm tubes from the Gulf of Manaar.

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EXPLANATION OF PLATES.

PLATE I.

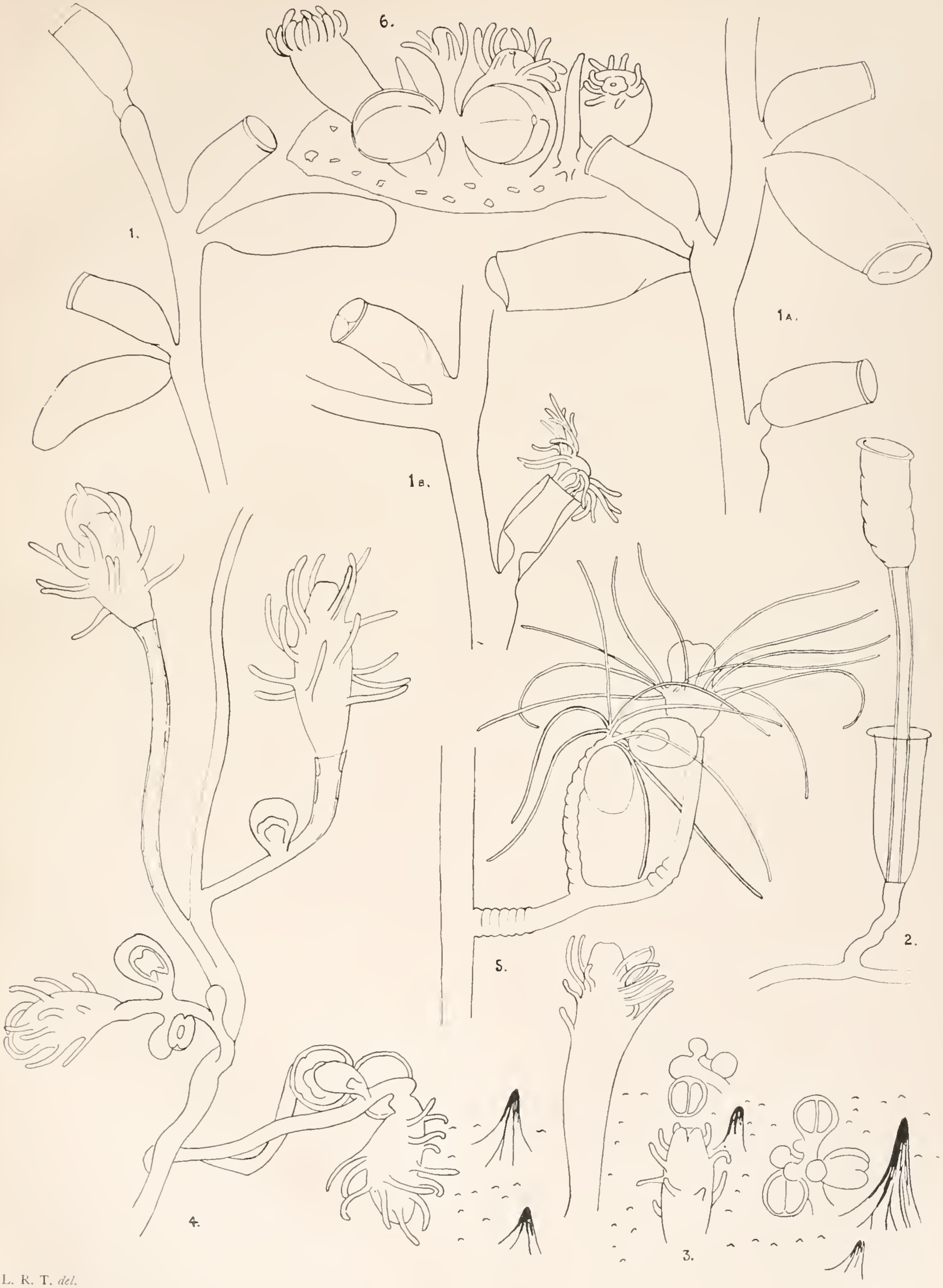
Fig. 1. *Campanularia juncea*, showing male gonothecæ.
,, 1A. ,, ,, female gonothecæ.
,, 1B. ,, ,, operculum and zooid.
,, 2. *Campanularia corrugata*, n. sp.
,, 3. *Clavactinia gallensis*, n. sp.
,, 4. *Corydendrium chevalense*, n. sp.
,, 5. *Eudendrium pusillum*, v. LENDENFELD.
,, 6. *Podocoryne denhami*, n. sp.

PLATE II.

Fig. 1. *Sertularia ligulata*, n. sp. Nat. size.
,, 1A. ,, ,, portion enlarged.
,, 1B. ,, ,, gonotheca.
,, 2. *Sertularia fissa*, n. sp. Nat. size.
,, 2A. ,, ,, front of hydrotheca.
,, 2B. ,, ,, back ,,
,, 2C. ,, ,, gonotheca.
,, 2D. ,, ,, showing modes of branching.
,, 2E. ,, ,, ,, ,,
,, 2F. ,, ,, ,, ,,
,, 3. *Sertularia gracilis*, HASS., showing attenuated form.
,, 4. *Sertularia rugosissima*, n. sp.
,, 5. *Sertularia tenuis*, BALE, showing abnormal mode of branching.
,, 6. *Diphasia mutulata* (BUSK), male gonotheca.
,, 6A. ,, ,, smaller form.
,, 6B. ,, ,, showing alternate hydrothecæ.
,, 7. *Desmoscyphus palkensis*, n. sp.
,, 7A. ,, ,, hydrothecæ.
,, 7B. ,, ,, gonotheca.

PLATE III.

Fig. 1. *Lytocarpus* (?) *hornelli*, n. sp. Nat. size.
,, 1A. ,, ,, hydrothecæ.
,, 1B. ,, ,, series of nematophores.
,, 2. *Lytocarpus plumosus*, n. sp. Nat. size.
,, 2A. ,, ,, hydrothecæ.
,, 2B. ,, ,, phylactocarps.
,, 3. *Lytocarpus fasciculatus*, n. sp. Nat. size.
,, 3A. ,, ,, hydrothecæ.
,, 3B. ,, ,, phylactocarps.
,, 4. *Clytia geniculata*, n. sp.
,, 4A. ,, ,, gonotheca.
,, 5. *Thuiaria palans*, n. sp.
,, 5A. ,, ,, hydrothecæ.



L. R. T. *del.*

Fig. 1. *Campanularia juncea.* Fig. 2. *Campanularia corrugata.* Fig. 3. *Clavactinia gallensis.* Fig. 4. *Corydendrium chevalense.* Fig. 5. *Eudendrium pusillum.* Fig. 6. *Podocoryne denhami.*

L. R. T. *del.*

Fig. 1. *Sertularia ligulata.* Fig. 2. *Sertularia fissa.* Fig. 3. *Sertularia gracilis.* Fig. 4. *Sertularia rugosissima.* Fig. 5. *Sertularia tenuis.* Fig. 6. *Diphasia mutulata.* Fig. 7. *Desmoscyphus palkensis.*

L. R. T. *del.*

Fig. 1. *Lytocarpus hornelli.* Fig. 2. *Lytocarpus plumosus.* Fig. 3. *Lytocarpus fasciculatus.* Fig. 4. *Clytia geniculata.*
Fig. 5. *Thuiaria palans.*

REPORT

ON THE

POLYCLAD TURBELLARIA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

FRANK FORTESCUE LAIDLAW, B.A. CANTAB.

[WITH ONE PLATE.]

THE seas lying about the island of Ceylon appear to support a particularly rich Planarian fauna. Although a greater number of species have already been described from these waters than from any other part of the world, the Mediterranean Sea alone excepted, I have not been able to identify any of the species mentioned below with any already described from them.

A large collection was made by SCHMARDA,* who describes no fewer than twenty-nine species from the Ceylon seas, whilst nineteen others are recorded by Dr. COLLINGWOOD.† Coloured figures carefully executed are available for all these species, so that I believe I have not overlooked any identities. Unfortunately neither of these writers was able to give sufficient account of the internal anatomy of the species they described, consequently the generic determination of their species is often a matter of uncertainty, and hence it is not possible at present to compare the general characters of this fauna with that of other parts of the world.

LANG‡ apparently makes no additions to the list; and since the publication of

* 'Neue wirbellose Thiere, beobachtet und gesammelt auf einer Reise um die Erde 1853 bis 1857,' I Band, "Turbellarien, Rotatorien und Anneliden," I. Hälfte, Leipzig, 1859.

† 'Trans. Linnean Society,' 2nd Series, Zoology, vol. I., p. 83, Plates XVII.-XIX. Three species, *Planaria aurea*, *Penula fulva* and *Penula alba*, are omitted by Dr. COLLINGWOOD from his account of KELAART'S species. See KELAART, 'Journ. Ceylon Branch Roy. Asiat. Soc.,' 1856-1858, pp. 134-139.

‡ 'Fauna und Flora des Golfes von Neapel,' XI., Polycladen, 1884.

LANG's monograph I can find no further records, save of *Cestoplana ceylanica* added by myself.*

Three of the species described below were collected in Ceylon by Mr. GARDINER in 1899. He has been good enough to permit me to incorporate my account of them with that of the species with which Professor HERDMAN has kindly entrusted me.

Paraplanocera aurora, LAIDLAW.

Paraplanocera aurora, LAIDLAW, 'P.Z.S.,' 1903, vol. II., Part I., p. 102, Plate IX., fig. 1.

One specimen which agrees in every respect with the type specimen from Zanzibar, save that it is nearly twice as large, being about 30 millims. in length, whilst Mr. CROSSLAND's specimen was only 15 millims. long. The Ceylon specimen was found at Station XVI., on the Periya Paar, in the Gulf of Manaar, at a depth of 9 fathoms.

Woodworthia, n. gen.

Closely allied to *Idioplana*. Body rounded, no notch on the anterior margin. A complete series of marginal eye-spots present. Prostate provided with a duct which joins the vesicular duct at the base of the penis. Female aperture separated from male; vagina of great length, having a bilaterally symmetrical accessory vesicle.

Woodworthia insignis, n. sp.—Plate, figs. 1 and 9.

One specimen, pearl banks, Gulf of Manaar.

Measurements.—Length, about 25 millims.; breadth, about 22 millims. Buccal opening sub-median. Male aperture about 4 millims. from hind end of body; female aperture about 0·5 millim. behind male. Tentacles 5 millims. apart.

Coloration.—In the spirit specimen an uniform whitish brown, in the living creature probably white. Scattered irregularly over the whole dorsal surface are numerous minute black dots of pigment.

Eye-spots.—These are grouped in a dense cluster at the foot of each tentacle, over the brain, and round the margin of the body. The spots over the brain are few in number and rather widely scattered. Those on the margin are very minute and are irregularly arranged; on the front part of the margin they may be two or three rows deep.

Body-wall.—The epidermis, both on the ventral and on the dorsal sides, contains numerous long, rather slender rhabdites, those on the dorsal side being nearly half as long again as those on the ventral side.

The basement membrane is remarkably thick. The muscles of the body-wall consist on the dorsal side of a longitudinal layer next the basement membrane, followed by diagonal fibres, and on their inner side a circular layer. On the ventral

* LAIDLAW, in GARDINER's 'Fauna and Geography of the Maldive and Laccadive Archipelagoes,' vol. I., Part III., p. 302, fig. 72.

side there is, in addition to these, an inner diagonal layer, and, lastly, an inner longitudinal layer.

Gut.—The pharynx is large and folded, of the type usually found in Planoceroids. The gut branches are very numerous and anastomose freely. The cells forming the epithelium appear to have broken away, in most cases, from the gut-wall, and to have rounded themselves into little spheres which lie free in the lumen. This is possibly due to some delay in fixing the tissues after the specimen was taken from the dredge.

Genital Apparatus.—The ovaries are dorsal; the testes cannot be distinguished in my sections, although the ends of the vasa deferentia are crowded with spermatozoa. The relations of the rather complicated terminal parts of the genital ducts will be rendered more easily comprehensible by a reference to the accompanying Plate, fig. 9.

Terminal Male Organs.—The small conical penis (*pe.*), which is unarmed, projects into the antrum masculinum (*a.m.*), which is a simple chamber lined with what appears to be a secreting, non-ciliated epithelium. Into the base of the penis run two ducts: one, that lying more dorsally, conveying secretion from a small muscular prostate gland (*pr.*), the other, the more ventral of the two, runs backwards and downwards for some distance to widen into a vesicula seminalis (*v.s.*). This latter duct is lined with ciliated epithelium and has rather thick muscular walls. It widens quite gradually into the vesicula, which receives on its dorsal side, some way behind its anterior end, the two vasa deferentia (*v.d.*), which, as they approach the vesicula, become endowed with muscular walls, composed, as in the case of the vesicula and its duct, of circular fibres.

The prostate duct is very short and enters the prostate immediately after it passes out of the penis. The interior of the prostate is divided into three longitudinal chambers (see Plate, fig. 1) by the folding of its secretory wall, outside which is a thick layer of circular muscle fibres traversed by a few radial and longitudinal strands.

Female Terminal Ducts.—The vagina is chiefly remarkable for its extreme length. The antrum (*a.f.*) is small, it opens vertically upwards. From it the vagina (*va.*) runs straight forward close to the dorsal body-wall. It consists here of a tube of rather narrow diameter, lined with ciliated epithelium, and surrounded by a few circular muscle-fibres. It continues forward until it has passed right beyond the level of the male organs. Its diameter then increases and it bends downwards and forwards for some distance, then turns upwards, receiving the secretion of the large shell glands (*sh.gl.*) at this level. Finally, near the dorsal body-wall, it turns sharply backwards, running parallel to the first part of its course and at about the same level with it, so that the two parts often lie side by side. At a level considerably in front of the extreme front end of the male apparatus the backwardly-directed part of the vagina receives the common duct running into it from the two uteri (*c.d.*). This duct is rather longer than is usual. The backward course of the vagina is continued until

the level of the antrum femininum is almost reached. The structure of this part is similar to that of its first part. Finally it ends by opening in the middle line into a large crescentic accessory vesicle (*acc.ves.*), whose "horns," lying one on either side of the middle line, are directed forward. The two halves of the accessory vesicle end in large, rather rounded lobes (*l.*). Its walls are composed of an active secretory epithelium which is at first columnar, but becomes more cubical in the lobes. These lobes contain a quantity of thick spongy secretion. In this secretion mass lie a large number of remarkable spindle-shaped bodies which vary considerably in size, and stain very deeply. They are shown in fig. 1, on the Plate. Each of these bodies lies in a small clear cavity which is spherical in shape. In the sections it is, of course, seen as a clear round patch, in which the dark-stained spindle-shaped body lies equatorially. The nature of these bodies is quite unknown to me, and the state of preservation of the tissues in the single specimen prevents a more detailed description. I am inclined to conjecture, however, that they may be spermatophores. In one or two cases the clear space surrounding them seems to be occupied by a gelatinous lightly-staining substance (*x*, in fig. 1, on Plate).

The most striking features of the genital apparatus of this species are (i) the great length of the vagina and (ii) the shape of the accessory vesicle, which is, roughly speaking, bilaterally symmetrical. The first of these peculiarities is paralleled in *Idioplana australiensis*, a species described by WOODWORTH.* This species also resembles that under discussion in the following respects:—Distribution of the eye-spots, coloration, and structure of the terminal parts of the male ducts. Consequently we may conclude that the two are closely related.

Idioplana, however, differs from *Woodworthia* in shape, in possessing a peculiar notch on the anterior margin, and in the fact that the prostatic duct and the vesicular duct open to the exterior almost independently of one another.

Woodworthia, on the other hand, possesses an accessory vesicle which is bilaterally symmetrical. These differences are sufficient to warrant a generic separation of the two forms.

Stylochus ceylanicus, n. sp.

Three specimens from Cheval Paar.

Measurement (of largest specimen).—Length, about 47 millims.; breadth, 27 millims. Genital aperture 4 millims. from hinder end of body. Tentacles 4 millims. apart. Buccal opening sub-central.

Coloration.—Judging from the preserved specimens, this must be, on the dorsal surface, a dull yellow covered with very numerous small ill-defined black spots which are absent in the area lying just over the brain. Ventral surface plain yellowish-white.

Eye-spots.—Numerous spots lie close together about the base of either tentacle;

* WOODWORTH, 'Bull. Mus. Harvard,' vol. XXXII., No. 4, p. 63, Plate XXXII., figs 2–5, 1898.

there are a number of scattered eye-spots about equal in size to those lying at the base of the tentacles, over the brain. In addition there are very numerous smaller spots on the margin. These do not extend completely round the body, but only about halfway along the margin on either side. They form anteriorly two or three irregular rows.

Genital Organs.—The ovaries are dorsal. The most striking peculiarity of this species is found in connection with the hinder ends of the vasa deferentia just before they enter the vesicula seminalis. They are provided in that neighbourhood with very thick muscular walls, which are quite as thick as the walls of the vesicula seminalis itself. The prostate is divided into a number of parallel chambers, its walls are formed of muscle-fibres which have a very definite "lattice-work" appearance.

In one specimen the penis was completely everted. The vagina opens into the same wide shallow depression as that into which the antrum masculinum passes.

This species may be defined as a *Stylochus* with an incomplete series of marginal eye-spots, with the ovaries occupying a dorsal position, and with the genital apertures closely approximated. The prostate is divided into a number of parallel chambers, and the lower ends of the vasa deferentia are highly muscular.

Stylochocestus, n. gen.

Body elongated, with neither marginal nor tentacle eye-spots. Buccal aperture sub-central.

Prostate gland large, provided with a short duct which joins the vesicular duct at the base of the penis. Vagina without accessory vesicle.

Stylochocestus gracilis, n. sp.—Plate, fig. 7.

Several specimens (Gardiner).

Measurements.—Length, about 14 millims.; breadth, about 3 millims. Male aperture 4·5 millims. from hinder end of body; female aperture 0·5 millim. behind male. Buccal opening sub-median.

I have no information as to the *coloration* of this species during life.

The *eye-spots* are arranged in two parallel rows over the brain.

Body-wall.—The epidermis of the dorsal surface contains rather large rhabdites, and in places also pseudorhabdites equal in length to the rhabdites, but much broader and rather irregular in outline. These are both absent from the ventral surface, except towards the margin of the body, whilst the ventral epithelium is flatter.

The basement membrane is thin, but stains deeply. The muscles lying immediately below it on the dorsal side are first a longitudinal layer, then a double diagonal layer, and lastly a circular layer. On the ventral side this is again succeeded by an inner longitudinal layer.

The *gut branches* do not anastomose.

Genital Apparatus.—The testes, which are very numerous and of large size, lie between the gut branches at almost the same level as the ovaries, being only a trifle more ventral in position.

Terminal Ducts (see Plate, fig. 7).

Male.—The two vasa deferentia (*v.d.*) enter the anterior end of a small vesicula seminalis (*v.s.*) which lies close against the dorsal body-wall. It is lined with a ciliated epithelium, outside which is a narrow layer of circular muscle fibres; it tapers at its posterior distal end into a duct (*d.e.*) without muscular walls, but with rather a wide lumen which runs to the penis (*pe.*). At the base of the penis it joins another duct which runs a short course directly from the penis to the prostate gland (*pr.*), an elongate oval body of about twice the size of the vesicula seminalis, lined with a well-developed secretory tissue enclosed in a layer of circular muscle fibres. The prostate duct is very short. The antrum masculinum (*a.m.*) is of moderate size, and in one of the specimens from which I prepared sections it is full of the secretion from the prostate.

Female Ducts.—The vagina (*va.*) runs upwards from the female aperture, then close to the dorsal body-wall it turns forward for a short distance and ends receiving the two uteri. The shell-glands (*sh.gl.*) lie about the first part of its course.

Thalamoplana, n. gen.

Closely allied to *Discocelis.* Male and female apertures separated. Antrum masculinum very large; its walls carry muscular projections, at the free ends of which lie the prostatic glands. The penis is of large size, truncate, and also carries prostatic glands at its end. In other respects the genus is similar to *Discocelis.*

Thalamoplana herdmani, n. sp.—Plate, figs. 2–5 and 8.

Two specimens were found in the lagoon at Galle.

Measurements.—Length, about 25 millims.; breadth, 17·5 millims. Buccal opening, 12 millims. from anterior end; male opening, 2 millims. behind buccal; female opening, close behind, but quite distinct from male.

Coloration.—Dorsal surface white with brown mottling. Along the mid-dorsal line is a brown frond-like pattern consisting of a median stripe bearing lateral lobes or segments in pairs, which are irregular in shape and size, but, roughly speaking, smaller and larger pairs alternate. The ventral surface is white.

Eye-spots.—These are arranged much as in *Discocelis tigrina* (see fig. 3 on Plate). On either side of the brain is a small elongate cluster of spots; these clusters diverge from each other posteriorly. Between them lie several diffusely scattered spots over the brain. Marginal eyes are also present on the anterior margin.

Body-wall.—The epidermis consists of columnar ciliated cells which are of considerably greater length on the ventral side of the body than on the dorsal. There are no rhabdites, but the cells appear to contain secretions of the nature of

pseudorhabdites. The basement membrane is very thick, especially on the dorsal side; on the other hand, the muscles of the body-wall are but feebly developed.

The *pharynx* is large and much folded. The *gut-branches* are numerous; there is no anastomosis.

Genital Apparatus.—Reference to the Plate, fig. 8, will render the account given below more readily intelligible.

Terminal Male Organs.—The two wide vasa deferentia (*v.d.*) unite to enter a median duct running to the penis. The proximal end of this duct is slightly swollen and has rather thick muscular walls; this part may be regarded as a vesicula seminalis (*v.s.*). Beyond it the duct (*d.e.*, ductus ejaculatorius) runs into the penis (*p.*), a large fleshy organ which projects backwards and downwards into the spacious antrum masculinum (*a.m.*). At its free end the penis is studded with a ring of curious large glands evidently of a prostatic character (*pr.gl.*), which lie around the rather wide opening of the lumen of the penis. These glands appear to be precisely similar in character to those found in *Discocelis tigrina.* As in that species, other glands of the same character are found on the walls of the antrum, but in the present instance they lie at the free ends of certain curious muscular prominences which project from the walls of the antrum. They are distributed as follows:—In front of the penis there is a crescentic muscular ridge which carries a number (about 15) of these glands. In the diagram it is shown in section at *m.pr.′*, the glands are marked *pr. gl.*, and they project at their distal ends to some extent from the surface of the ridge.

Behind the penis there lies on either side of the middle line a pair of prominences shaped rather like the penis, but folded in towards each other. Like the penis, they each carry glands, 3 or 4 apiece at their free ends. They are indicated on the diagram at *m.pr.*^{2} (see too, Plate, fig. 4). The floor of the antrum is formed of a very thin fold of the integument, which extends backward as far as the level of the paired prominences spoken of above. The antrum is lined throughout with a thin layer of flattened epithelium which bears very short cilia.

The glands have a length of about 0·1 millim. They are pear-shaped, their narrower end is directed outwards and ends in a conical point which passes through the epithelium lining the antral walls (Plate, fig. 5, *a.gl.*). The gland is in every case filled with a fine darkly staining network, in the interstices of which in some of the glands lies a quantity of finely granular secretion. The nuclei lie about the walls of the gland, none occur in the reticulum. The walls are without muscle fibres.

Female Terminal Ducts.—These bear a very strong resemblance to those of *Discocelis tigrina.* The female aperture opens into the terminal part of the vagina (*va.*), which is at first rather wide and runs in a dorsal direction. It then turns backwards, its lumen narrows, and its muscular walls become thicker. After receiving the common opening of the uteri (*ut.*) it is prolonged back for some distance. This hinder part may be termed the accessory part of the vagina (*acc.* in

diagram). It is wider than that part immediately in front of the uterine opening, its walls are thinner, and the lining epithelium is flattened and non-ciliated, whilst in the anterior part the lining epithelium is columnar or square and appears to be ciliated. At its hinder end the accessory part of the vagina opens into the accessory vesicle (*acc.ves.*) which has no muscular walls; its lining epithelium consists of large square secretory cells, and in its lumen lies a lump of secreted substance.

The shell glands are very large, they pass their secretion into the anterior part of the vagina (*sh.gl.*). A very curious feature is the presence of a considerable fold of the body-wall (*pl.*) on either side of the female aperture. This is easily visible in the whole specimen when examined with a simple lens, and in conjunction with the still more prominent external male organs serve to distinguish this species at a glance from any other with which I am acquainted. The position of the ovaries is dorsal.

This is certainly the most interesting species in the collection. It is the type of a genus which may be regarded as a specialized form of *Discocelis* which has retained a single primitive feature which the latter has lost, namely, the widely separated genital apertures.

The feature most worthy of remark is the development of muscular projections of the walls of the antrum to carry the prostatic glands, which are sessile in *Discocelis*. They are of importance, since they suggest a probable explanation of the manner in which the curious intromittent prostate organ of the Diposthiidæ may have arisen, and because they further give an indication of the manner in which a re-duplication of the penial organs may have come about. In fact, if the genus *Discocelis* were not known, one would be almost tempted to suppose that *Thalamoplana* was derived from an ancestral form possessed of a large number of penes, which are here to be seen in process of reduction.

The three genera *Semonia*,* *Discocelis*,† and *Thalamoplana* may conveniently be grouped in a distinct sub-family of the Leptoplanidæ, characterized by the possession of marginal eye-spots, of a large blunt penis, and by the absence of an internal prostate gland. *Semonia*, like *Discocelis*, has a common genital atrium, whilst *Thalamoplana* resembles *Discocelis* in possessing external prostatic glands and a bilaterally symmetrical accessory vesicle connected with the vagina.

Leptoplana gardineri, n. sp.

One specimen, collected by Mr. Gardiner in 1899.

Colour in spirit specimen uniform yellowish-white.

Measurement.—Length, about 16 millims.; breadth, 7·5 millims. Buccal opening sub-central. Female aperture about 6 millims. from the hinder end of the body.

* Von Plehn, 'Jen. Zeitschr. f. Naturwissenschaft,' Band XXX., pp. 157–159, Taf. XI., figs. 5, 12; Taf. XIII., fig. 3. See also Laidlaw, 'Proc. Zool. Soc.,' 1903, p. 309.

† See especially Lang, *loc. cit.*, Taf. XIII., fig. 1.

The arrangement of the *eye-spots* is shown in fig. 6 on Plate.

This species is a true *Leptoplana* belonging to the section of the genus* in which the penis is not armed with a stylet. The prostate is chambered, with some five compartments, it is small and of considerable length.

L. gardineri is nearly related to *L. chierchiæ*, VON PLEHN, from which it is readily distinguished by the very different arrangement of the eye-spots, by the greater relative length of the prostate, and by the relatively small size of the accessory vesicle of the vagina.

Pseudoceros, sp.

One specimen, referable to this genus, from the pearl banks, Gulf of Manaar, is unfortunately not in suitable condition for accurate description. It apparently belongs to the section of the genus which is provided with only a single penis; the colour is white with a fine black margin. The total length of the specimen is about 20 millims.

Prosthiostomum singulare, n. sp.

One specimen from Ceylon (GARDINER).

Measurements.—Length, about 40 millims.; breadth, about 6 millims. Buccal opening 6 millims. from the anterior end. Male aperture 16 millims. behind buccal opening; female aperture 1·5 millims. behind male. Sucker 2 millims. behind female aperture.

The *colour* of the spirit specimen is uniform white.

The marginal *eye-spots* are relatively very small and lie in an irregular row round the front margin, extending back on either side for 3 or 4 millims. There are no "brain-eyes"; in this respect *P. singulare* differs from all other known members of the genus.

Genital Organs.—The outer chamber of the antrum masculinum is very large and is provided with thick muscular walls, in which on the dorsal side the accessory vesicles, the vesicula seminalis and part of their ducts are embedded. The accessory vesicles are relatively small and their ducts short. In other respects the sexual organs are exactly as in *P. siphunculus*.

* In my list of the species of the genus *Leptoplana* given in the 'Proc. Zool. Soc.,' 1903, pp. 307, 308, *L. nationalis*, v. PLEHN, was by mistake referred to a division of section A of the genus which included species in which the prostate gland is not chambered. It should, of course, be put in the division A (*b*) near *L. vitrea*, LANG.

EXPLANATION OF PLATE.

Fig. 1. Part of a transverse section across the body of *Woodworthia insignis*. Epidermis and gut shown quite diagrammatically. The section is in the plane AB, shown in fig. 9, and the part drawn shows the median organs and those a little to the right of the middle line.

,, 2. *Thalamoplana herdmani*, sketch of the appearance of the entire animal, showing the colour pattern. × 4 diam.

,, 3. Dorsal eye-spots of the same.

,, 4. Section across the hinder end of the antrum masculinum of the same, in the plane marked AB in fig. 8. The epidermis and body-wall muscles are shown diagrammatically. The two glands (*pr.gl.*) are secreting actively and contain a finely granular secreted substance.

,, 5. Section across three prostatic glands of the same more highly magnified. These glands are exhausted and show only the protoplasmic reticulum.

,, 6. Eye-spots of *Leptoplana gardineri*.

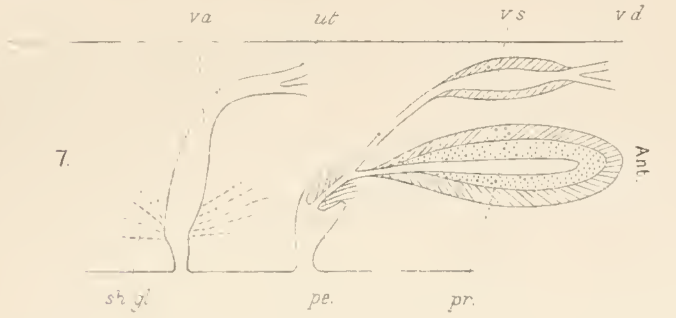
,, 7. Diagram of genital ducts of *Stylochocestus gracilis*, n. gen. and sp.

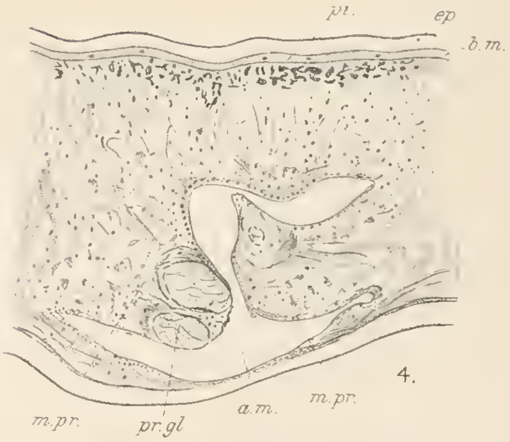
,, 8. Diagram of genital ducts of *Thalamoplana herdmani*, n. gen. and sp.

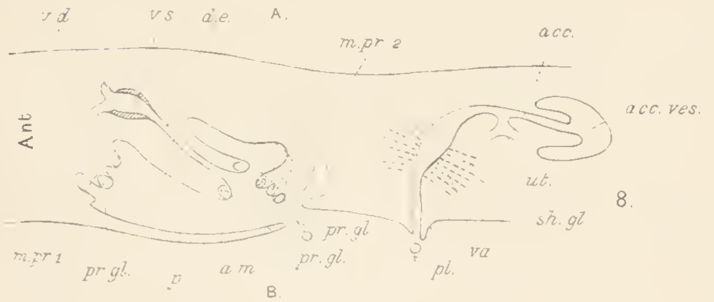
,, 9. Diagram of genital ducts of *Woodworthia insignis*, n. gen. and sp.

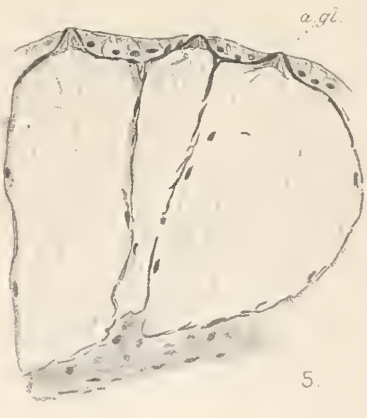
Explanation of Lettering.

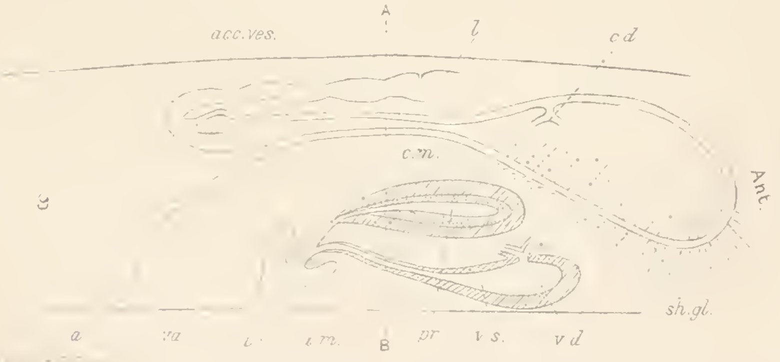
a.f., antrum femininum.
a.gl., aperture of prostatic gland.
a.m., antrum masculinum.
acc.ves., accessory vesicle.
b.m., basement membrane.
c.d., common uterine duct.
c.l., circular muscle layer.
d.e., ductus ejaculatorius (vesicular duct).
d.l., diagonal muscle layer.
e.l., external longitudinal muscle layer (ventral).
ep., epidermis.
g., gut.
i.l., inner longitudinal muscle layer.
l., lobes of accessory vesicle.
m.pr., muscular projection from antrum.
n., nervous tissue.
pe., penis.
pi., pigment.
pr., prostate.
pr.gl., prostatic gland.
sh.gl., shell gland.
tr.m., dorsiventral muscles.
ut., uteri.
v.s., vesicula seminalis.
v.d., vas deferens.
va., vagina.
va[2]., accessory part of vagina.
x., dark body in the accessory vesicle surrounded by gelatinous substance.











FIGS 1 AND 9 WOODWORTHIA INSIGNIS FIG 6 LEPTOPLANA GARDINERI

FIGS 2 5 AND 8. THALAMOPLANA HERDMANI FIG. 7 STYLOCHOCESTUS GRACILIS

REPORT

ON THE

ECHINODERMA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

W. A. HERDMAN, D.Sc., F.R.S., AND JANE B. HERDMAN, B.Sc. (LOND.),

WITH NOTES AND ADDITIONS

BY

F. JEFFREY BELL, M.A.,

EMERITUS PROFESSOR AND FELLOW OF KING'S COLLEGE, LONDON.

[WITH TEXT-FIGURES.]

[EDITORIAL NOTE.—The HOLOTHURIOIDEA of this collection were described in Mr. PEARSON'S Report published in PART I. (p. 181, 1903), and the CRINOIDEA are reported upon separately by Mr. CHADWICK in this Part (see p. 151, below).

The greater part of the labour in connection with the remaining groups of Echinoderma has been undertaken by my wife, who separated out most of the species and identified the Echinoidea. I should naturally have let her name stand alone in the title of the Report, but as I took some part in the work, exercised a general supervision and identified the commoner starfishes, she prefers that I should be jointly responsible.

Professor JEFFREY BELL, while on a short visit to us in September, kindly went over the greater part of the collection with me and confirmed the identifications. Most of the Ophiuroids and some of the smaller or more doubtful Echinoids and Asteroids were, at his suggestion, sent to him at the British Museum, with the result that he has contributed some additions to our list, and the interesting Notes on some forms and remarks on the more general aspects of the collection, which will be found under his own name at p. 148.—W. A. H.]

ECHINODERMA.

In the year 1882, we are told by Bell, only 4 species of Echinoderms were known from Ceylon. Haeckel's collection, described by Walter, added 16 species, but most of our knowledge is due to the successive collections made for the British Museum by Dr. Ondaatje, which enabled Bell to add about 20 species in 1882 and to raise the number to over 50 in 1887. The collection of P. and F. Sarasin, made at Trincomalee in 1884–86, yielded to Döderlein 16 species of Asteroids, 10 Ophiuroids, and 18 Echinoids. Adding these, along with 16 Holothurians (Ludwig) and 5 Crinoids (Bell), to the forms previously known raised the total in 1888 to about 90 species. A few species have since been added by Thurston and others.

There seem to be about 109 species of Ceylon Echinoderms in all in the present collection. Mr. Pearson recorded 30 species of Holothurioidea, and Mr. Chadwick gives 13 species of Crinoidea in the Report that follows this. In the present lists we have 28 species of Echinoidea, 24 species of Asteroidea, and about 14 species of Ophiuroidea. There were no forms unknown to science in the three last-named groups, but some of the species are of interest from the point of view of distribution, habitat and variation.

ECHINOIDEA.

DESMOSTICHA.

CIDARIDÆ.

Cidaris metularia (Lamk.).

Station XL., 10 miles off Galle, 34 fathoms, 2 specimens, about 1 centim. diameter; Station LV., south-west of Periya Paar, 11 to 24 fathoms, 2 specimens, 1 centim. and 1·5 centim. diameter; Station LXIII., west of Periya Paar, 36 fathoms, 1 specimen, about 1 centim. diameter.

Stephanocidaris bispinosa (Lamk.).

Pearl banks, Gulf of Manaar; 4 specimens. Also another "very young Cidaris."

Phyllacanthus baculosa (Lamk.).

Many specimens were dredged from 10 to 12 miles off Galle, at Stations XL. and XLI., depths 34 to 100 fathoms. Also further on up the west coast of Ceylon, towards Colombo, and off Kaltura and Mount Lavinia, at Station XLVI., depth 25 to 30 fathoms. Also in the Gulf of Manaar, at Station LIV., south of Adam's Bridge, 4 to 40 fathoms; at Station LV., south-west of Periya Paar, 11 to 24 fathoms; at

Station LX., outside Donnan's Paar, 20 to 30 fathoms, and from Cheval Paar, 7 fathoms. obtained by the divers. The diameters of the specimens, without the spines, ranged from 1 centim. to 4·5 centims.

Phyllacanthus imperialis (Lamk.).

One specimen from the Gulf of Manaar, at Station LVII., outside Dutch Modragam Paar, 12 to 36 fathoms; it measures about 2 inches in diameter, without the spines, and about 6 inches including them.

DIADEMATIDÆ.

Diadema saxatile (Linn.).

One small specimen was obtained at Station XL., 10 miles off Galle, depth 34 fathoms. This specimen has long spines on the upper surface, banded straw-coloured and red.

Echinothrix diadema (Linn.).

Obtained at Station XL., 10 miles off Galle, depth 34 fathoms.

ECHINOMETRIDÆ.

Stomopneustes variolaris (Lamk.).

Many specimens were found at the south-eastern corner of Welligam Bay, south end of Ceylon, in hollows in rock pools and also under the sea, in cavities and crevices of the rock. They were of a very deep purple colour when alive, but are now, both the dried and the spirit specimens, of a greenish-black colour. This species was also observed in the lagoon inside the reef at Galle.

Pseudoboletia maculata, Trosch.

One specimen, diameter about 6·5 centims., was obtained from the Cheval Paar, 7 fathoms, by native diver.

Echinostrephus molare (de Bl.).

This little species was obtained in coral blocks in the Gulf of Manaar, at Station XV., on Periya Paar, 9 fathoms, 2 specimens; at Station LXII., between Periya Paar Kerrai and Periya Paar, depth 7 fathoms to 13 fathoms, 2 specimens, 1·5 centims. and 2 centims. in diameter; and on the Jokkenpiddai Paar, obtained by native divers, many specimens, 1 centim. to 1·5 centims. in diameter.

All the specimens of this little purple Echinid were dug out of deep holes in massive blocks of dead coral; and the top-shaped or obovate form of the test, with all the long spines on the abactinal surface, seems well adapted to the burrowing habit. It was noticed on the living specimen that the shorter spines on the actinal surface around the mouth are arranged so as to show a spiral twist such as would be produced by a rotation of the animal within its burrow.

TEMNOPLEURIDÆ.

Temnopleurus toreumaticus (Leske).

A number of small Temnopleurids, which probably belong to this species, were obtained (1) south of Galle, in deep water, and (2) at Station LXIII., west of Periya Paar, 36 fathoms, 9 specimens, of 1·5 centims. to 2 centims. diameter.

Temnopleurus, sp. ?

Some small cream-coloured Temnopleurids were obtained from Station XV., on Periya Paar, 9 fathoms; 10 miles off Galle, in deep water; on the Cheval Paar (off Aripu), 7 fathoms; and at Station I., west of Negombo, 12 fathoms to 20 fathoms.

Salmacis bicolor, Agass.

This species was obtained (1) off Galle, Station XXXIX., depth 16 fathoms to 30 fathoms; (2) south-west of Periya Paar, Station LV., depth 11 fathoms to 24 fathoms; (3) at various localities on Cheval Paar and other pearl banks off Aripu, depth 6 fathoms to 7 fathoms; and (4) at Station XVIII., in Palk Bay, 7 fathoms.

The specimens range from 1 centim. to 6·5 centims in diameter.

Salmacis dussumieri, Agass.

This species was obtained (1) at Station II., north-west of Negombo, 8 fathoms, 12 specimens, from 2 centims. to 4 centims. in diameter; (2) at Station XLVIII., between East and West Cheval Paars, depth 7 fathoms, many specimens, ranging from 0·5 centim. to 2·5 centims. in diameter; (3) at Station LXIII., west of Periya Paar, 36 fathoms; and at several other places on the pearl banks.

Salmacis sulcata, Agass.

Specimens were obtained (1) at Station I., off Negombo, 12 fathoms to 20 fathoms, 3 specimens, 1·5 centims. to 2·5 centims. in diameter; (2) at Station XLVIII., on the Cheval Paar; and at other localities amongst the pearl banks off Aripu, depths 6 fathoms to 8 fathoms, many specimens, ranging from 1 centim. to 4 centims. in diameter.

TRIPLECHINIDÆ.

Toxopneustes pileolus (Lamk.).

Three specimens were dredged in the Gulf of Manaar, from Station LV., south-west of Periya Paar, 11 fathoms to 24 fathoms; on North-west Cheval Paar, 8 fathoms; and again on Cheval Paar, 7 fathoms. They range in diameter from 7·5 centims. to 10 centims.

Most of the pedicellariæ of this species are very remarkable and striking, both in size and colour, when seen alive. They show the three valves connected by a large discoid membranous extension, which is of a beautiful deep-red colour edged by a

band of snowy white. In the preserved specimens the membrane is now contracted to a triangular peltate form, but the white band is still visible.

CLYPEASTRIDA.

EUCLYPEASTRIDÆ.

Fibularia australis, Desml. (?).

Many specimens, ranging from 6 millims. to 10 millims. in length, were dredged outside Dutch Modragam Paar, at Station LVII., 11 to 36 fathoms; and two specimens, 8 millims. and 12 millims. in length, were obtained in deep water outside Galle. These specimens have many more than 4 pairs of pores on the petals—generally 12 to 15 pairs are present.

ECHINANTHIDÆ.

Clypeaster humilis (Leske) = **C. rosaceus,** Linn., *fide* Lovén.

Dredged all round the coast of Ceylon, at Stations I., II., IV., IX., XI., XII., XIV., XXXVIII., XLIV., XLVI., XLVIII., XLIX., LI., LIII., LVII., LXIX. The specimens ranged from 1 centim. to 15 centims. in length.

This species seems commonest in depths of 8 to 10 fathoms on the pearl banks in the Gulf of Manaar.

Clypeaster scutiformis (Gmel.).

Two specimens, about 50 millims. and 40 millims. in length, were dredged to the west of the Periya Paar, at Station LXIII., 17 to 55 fathoms.

Two specimens, about 30 millims. long, were dredged in deep water 10 miles off Galle, at Station XL., 34 fathoms, and 6 miles west of Kaltura, depth 22 fathoms, at Station XLIII.

Echinanthus testudinarius (Gray).

At Station III., off Chilaw, 9 to 14 fathoms; at Station XLI., 12 miles south of Galle, about 100 fathoms; at Station XLIX., south of Cheval and Periya paars, about 12 fathoms.

Echinanthus, sp. ?

A young specimen which we cannot identify with certainty was dredged at Station LXVI., off Mutwal Island, 10 to 35 fathoms.

LAGANIDÆ.

Laganum depressum, Less.

Many specimens, ranging in length from 1·8 centims. to 4 centims., were dredged all round the coast of Ceylon, at Stations II., XII., XXI., XLIII., XLVI., XLVIII., LIII., LVI., and LVII.

They were particularly abundant at Back Bay, Trincomalee, in 8 to 12 fathoms.

SCUTELLIDÆ.

Echinodiscus auritus, Leske.

Dredged at many points on the west and south coasts of Ceylon, including Stations I., II., XI., XII., XIV., XXXIV., XXXVIII., XXXIX., XLIX., LI., LVI., LXII., and LXIX.

The specimens ranged from 1 centim. to 11 centims. in length.

PETALOSTICHA.

CASSIDULIDÆ.

Echinoneus cyclostomus, Leske.

One specimen, about 1·8 centims. in length, was dredged to the west of Periya Paar, at Station LXIII.; depth, 17 to 55 fathoms.

Echinolampas oviformis (Gmel.).

Dredged on the pearl banks, Gulf of Manaar, at Stations IV., XI., XLVIII., XLIX., LV., and LXIII.

The specimens ranged in diameter from 2 centims. to 10 centims.

SPATANGIDÆ.

Maretia planulata (Lamk.).

A few specimens, from 2 centims. to 3·5 centims. in length, were dredged in the Gulf of Manaar, at Station IV., opposite Karkopani, 6 to 9 fathoms; Station XLIX., south of Cheval Paar, 12 fathoms; Station LV. and LXIII., west of Periya Paar, 11 to 36 fathoms.

Maretia alta, A. Agass.

At Station XXXIII., south of Arugam Bay, east of Ceylon, 18 fathoms; off Galle; and south of Modragam.

Lovenia elongata (Gray).

Several specimens were dredged between Colombo and Palk Strait, and also off Welligam and Galle, at Stations I., IV., XI., XXXIV., XXXIX., XL., XLIII., XLVIII., XLIX., LV., and LXIII., at depths of 2 to 40 fathoms. They range in length from 2 centims. to 6 centims.

LESKIIDÆ.

Schizaster gibberulus, Agass.

One specimen (2·5 centims. in length) from Station LV., south-west of Periya Paar, 11 to 24 fathoms.

ASTEROIDEA.

ASTROPECTINIDÆ.

On the characters of the species of *Astropecten* see Professor BELL's Notes (p. 148, below).

Astropecten hemprichi, M. and T.

Stations I., IV., X., XIV., XX., XXVIII., XXXII., XXXIX., XLII., XLVII. and LIV., practically all round the island, at depths of 4 to 40 fathoms. It is especially abundant on some parts of the pearl banks.

Astropecten euryacanthus, LÜTKEN.

Station XX., Back Bay, Trincomalee, 11 to 13 fathoms.

Astropecten polyacanthus, M. and T.

Station XXVIII., Trincomalee, 7 to 14 fathoms; Station XXXVIII., off Galle, 9 to 22 fathoms; Station LX., outside Muttuvaratu Paar, 20 to 30 fathoms; Station XLIII., west of Kaltura, 22 fathoms; and Station LXIII., west of Periya Paar, 36 fathoms.

Astropecten indicus, DÖDERLEIN.

Off Galle. Also Station XXXIV., off Welligam, at south end of Ceylon, 7 fathoms.

Astropecten zebra, SLADEN.

Trincomalee. (See Professor BELL's Notes, p. 149, below.)

Luidia maculata, M. and T.

Abundant all round Ceylon, and especially in the shallow water of the pearl banks in the Gulf of Manaar, where we obtained specimens of all sizes from a couple of centimetres up to well over a foot across.

Luidia hardwickii (GRAY).

Pearl banks, Gulf of Manaar. Professor BELL reports that "from the same locality there is a very interesting young specimen which belongs either to some undescribed species, or is, as is quite likely, the armed young of an unarmed adult, for it is provided with spines on the surface of its rays."

PENTAGONASTERIDÆ.

Stellaster incei (GRAY).

Stations XX. and XXI., Trincomalee, many; between Colombo and Palk Strait;

off Galle, 16 to 20 fathoms; 12 miles south of Galle, 100 fathoms; Station XLIV., off Kaltura, 30 fathoms; Station LIV., south of Adam's Bridge, 4 to 40 fathoms.

Young Stellasters from Station XLIII., west of Kaltura, 22 fathoms; from Back Bay, Trincomalee, and from other localities, are in the collection.

ANTHENEIDÆ.

Anthenea sp?

In the lagoon of the reef at Galle.

Goniodiscus, sp. (?)

Professor Bell adds "? young *Goniodiscus*," from locality (?) in Gulf of Manaar.

Family: PENTACEROTIDÆ.

Pentaceros lincki, De Bl.

From lagoon inside reef, Galle. Common on the pearl banks in the Gulf of Manaar, and of importance as an enemy of the pearl oyster (see figure on p. 147).

Pentaceros mammillatus (M. and T.).

West of Periya Paar; at Station LXIV., south-east of Modragam Paar, 5 fathoms.

Pentaceros nodosus (Gray).

Station III., off Chilaw, 12 fathoms; Station XLII., off Barberyn, 40 fathoms; Station LIV., south of Adam's Bridge, 4 to 40 fathoms; Station LXIV., south-east of Modragam Paar, 5 fathoms.

Pentaceros, sp. (young).

Station XLIII., west of Kaltura, 22 fathoms.

Culcita schmideliana (Retz.).

Station LIX., Muttuvaratu Paar, 8 fathoms; and Station LX., outside Muttuvaratu Paar, 20 to 30 fathoms.

This cushion-like starfish is almost circular in outline when alive, but shows on the oral surface a bright orange-coloured pentagon closely papillated and with the ambulacral grooves running as narrow red lines out to the angles. On the aboral surface there are short red spines on the well-marked lobed areas, while the surface between has a fine fluffy or velvet-like appearance. The larger specimen measures 19 centims. in diameter and 10 centims. in height, and is much less spiny on the aboral surface than the smaller specimen, which is about 14 centims. in diameter and 8 centims. in height. The animal when alive has a much more globular form than have preserved specimens.

ASTERINIDÆ.

Asterina cepheus (M. & T.).

Station LXVI., off Mutwal Island, 10 to 35 fathoms; off Galle, in deep water; on Navakaddu Paar, April 2nd, 1902; Station IV., off Karkopani, 6 to 9 fathoms; Station XLI., 12 miles south of Galle, 100 fathoms.

LINCKIIDÆ.

Ophidiaster cylindricus (Lamk.).

Station XXXVIII., outside Watering Point, Galle, 9 to 22 fathoms.

Ophidiaster helicostichus (Sladen).

What may be the young of this little-known species was taken south of Galle, in deep water.

Linckia multiforis (Lamk.).

Specimens (including "comet forms") were obtained from Back Bay, Trincomalee; also at Station XXIII., 6 fathoms.

Linckia lævigata (Gmel.).

On the pearl banks in the Gulf of Manaar; and at Station XIV., west of Cheval Paar, 8 fathoms.

Linckia pacifica, var. **diplax** (*teste* Sladen).

Muttuvaratu Paar, Gulf of Manaar.

Nardoa tuberculata, Gray.

From lagoon inside the reef, Galle; and at Station LX., outside Muttuvaratu Paar, 20 to 30 fathoms.

Metrodira subulata (Gray).

Station XLIII., west of Kaltura, 22 fathoms.

PTERASTERIDÆ.

Retaster cribrosus, v. Mart.

At Station XLII., between Galle and Barberyn, 40 fathoms, one specimen (see Professor Bell's Notes, below).

ECHINASTERIDÆ.

Echinaster purpureus (Gray).

Station LXIV., south-east of Modragam Paar, 5 fathoms; Station VI., Muttuvaratu Paar, 6 to 9 fathoms; Station XIV., west of Cheval Paar, 8 fathoms; and other localities on the pearl banks, Gulf of Manaar.

OPHIUROIDEA.

Pectinura gorgonia (M. and T.).

Gulf of Manaar, pearl banks; Station LXIII., west of Periya Paar, 36 fathoms; Station X., off East Cheval Paar, 6 fathoms.

Both adult and young stages were found in abundance on the pearl banks.

Pectinura intermedia, Bell.

Gulf of Manaar, pearl banks; Station I., off Negombo, 12 to 20 fathoms.

Ophiura, sp.

From the Cheval Paar. This is not *O. kinbergi*, which is known from this neighbourhood.

Amphiura, sp.

At Station LIII., 10 miles north of Cheval Paar, 9 fathoms; Station XLVII., south of Cheval Paar, 9 fathoms; also off the south-east coast of Ceylon (see Professor Bell's Notes below, p. 149).

Ophionereis, **?** sp.

Young forms from the Cheval Paar, 6 to 8 fathoms.

Ophiocnemis marmorata (Lamk.).

Trincomalee, various localities, February, 1902; Gulf of Manaar, March, 1902; Station VI., Muttuvaratu Paar, 6 to 9 fathoms; Station XVII., west of Periya Paar, 11 fathoms; Station XX., Back Bay, Trincomalee, 11 to 13 fathoms.

Ophiocoma scolopendrina, Agass.

Station LX., outside Muttuvaratu Paar, 20 to 30 fathoms.

Ophiarachna incrassata, M. and T.

Very young specimens, probably of this species, were dredged in deep water off Galle.

Ophiothrix, spp. (**? O. aspidota, O. nereidina**, and others).

Station XLVI., off Mount Lavinia, 25 to 30 fathoms; Station LXIII., west of Periya Paar, 36 fathoms; off Galle, deep water, up to 100 fathoms; Station XLV., off Pantura, 25 fathoms; on Jokkenpiddai Paar, April 3rd, 1902; on Aripu Reef, shallow water.

Three "species" from Cheval Paar, from Trincomalee, and from Gulf of Manaar (see Professor Bell's Notes below, p. 150).

Ophiomaza cacaotica, LYM.

Gulf of Manaar, pearl banks; Station XV., on Periya Paar, 9 fathoms.

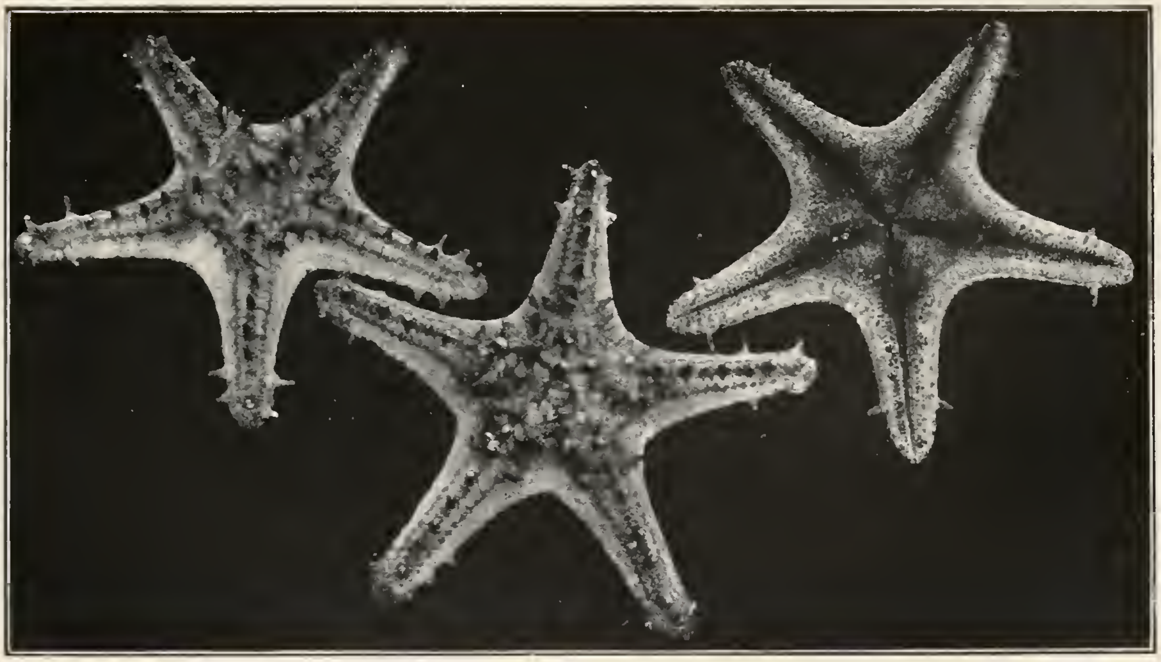
Ophiopteron elegans, LUDWIG.

Station LXIII., west of Periya Paar, 17 to 55 fathoms.

Ophiomyxa, ? sp.

Young specimens from deep water off Galle and from Trincomalee.

There are probably other species of Ophiuroids in the collection. A number of the smaller—possibly immature and in some cases imperfect—specimens remain unnamed. Professor BELL's remarks below refer to some of these.



Specimens of *Pentaceros lincki*, DE BL., from the Gulf of Manaar.

SOME NOTES ON THE ABOVE-NAMED COLLECTION OF ECHINODERMS.

BY

F. JEFFREY BELL, M.A.,

EMERITUS PROFESSOR AND FELLOW OF KING'S COLLEGE, LONDON.

I had the advantage of going through the eleutherozoic actinogonidiate Echinoderms with Professor HERDMAN himself, and he has included my determinations in the above list. The more difficult specimens I brought to London for determination in the National Collection, and on these, and on some general aspects of the subject, I take leave to say a few words.

(1.) The collection contains a large number of specimens of common Indo-Pacific Echinoderms and a goodly store of young forms; these it is most necessary to keep with their generic allies; the determination of their *species* is quite a trivial matter as compared with the importance of obtaining a rich and extensive series of stages, showing the variations due to increase in size, and also the numerous individual variations which wide-spread species of Echinoderms always exhibit.

(2.) The absence of some of the species which at present we are inclined to associate with Ceylon, such as *Asthenosoma urens*, *Fromia tumida*, *Ophiothela holdsworthi*, is to be deplored, but the general character of the collection leads us to suppose that these species are local even in Ceylon; the presence of *Ophiopteron elegans*, which Mr. STANLEY GARDINER obtained in his expedition to the Laccadives, confirms me in my view that this species is widely distributed in the tropical waters of the Indian Ocean.

(3.) On one important matter I have at last some hope that we are on the way to a solution. In 1887 the late P. M. DUNCAN* observed "One of the commonest species of the Ophiurida is a . . . . . form which is usually found without a top to the disk," but the fact, apart from the difficulty it produced as to naming the genus, did not appear to him to be of any interest.

In 1888† I somewhat pointedly drew attention to the same phenomenon, and I ventured to remark, "Naturalists who have the opportunity of observing this long-armed form in life should direct particular attention to this loss of the disk, with a view to answering such questions as to whether the loss is in any way associated with the act of reproduction, whether the disk becomes restored, and, if so, whether the restoration is effected rapidly."

* 'Journ. Linn. Soc. Zool.,' vol. XXI., p. 90.

† 'Ann. and Mag. Nat. Hist.,' p. 368.

Dr. Sluiter* has since put on record his regret that he did not become acquainted with my note, when he still had under his eyes Ophiuroids that were living in his aquaria without the dorsal covering to their disks. The phenomenon seems to be pretty common, and there are a number of interesting biological problems associated with it which should attract naturalists in tropical and subtropical seas.

After some search I lit on a long-armed Ophiuroid with the upper surface of the disk intact; it was soon easy to see that this was not the *Ophiocnida imbricata* in which Dr. Sluiter had noticed the phenomenon, and I was inclined to ascribe it to *Amphiura divaricata*, but the arms of that species, as described by Ljungman, are much shorter. It appears to be a true, but unnamed, Amphiuran.

(4.) I beg once more to offer an example of the variability of Echinoderms, and to call attention to the mode of distribution of the spicules on the superomarginal plates of *Astropecten hemprichi;* the three figures here shown are taken from the three

specimens found in the bottle to which the late Mr. Sladen affixed the name of *Astropecten zebra.* In the "Challenger" Report *A. zebra* occupies the following position in the author's "key":—

(A.) With small spinelet, on the first four or five plates.

(*a.*) With four or five spinelets. A well-developed series of pseudo-pedicellariæ . . . . *zebra.*

(*b.*) With one spine only on the first plate. No pedicellariæ . . *velitaris.*

Inspection of my photographs will show how little constant is the number of spinelets, and the uselessness of the character as an aid to specific distinction.

* 'Tijds Nederl. Dierk. Ver.,' v. (1898), p. 306.

A. zebra should, I think, be united with *A. hemprichi*.* Perhaps, also, SLADEN'S *A. notograptus* is another synonym.†

(5.) The evidence in favour of the great variability of Echinoderms is now overwhelming, and new species should only be made on the most solid grounds. The condition into which the genus *Ophiothrix* has been allowed to fall by the uncritical establishment of a multitude of species is such that I had to tell Professor HERDMAN that I could not undertake the determination of the numerous forms in his collection that appear to the cabinet naturalist to be very different, but which, if we may argue from what we know of the genus in our own seas, would be all brought up by one haul of the dredge. A critical revision of the described species of *Ophiothrix* by a naturalist of unlimited leisure would be a boon to the systematist; the uncritical addition to our list of forms "which appear to be distinct" is of no service whatever to science.

(6.) As in all carefully prepared collections, there are a number of small Ophiuroids, many more or less broken; I have referred all I can to their genus, and have sometimes made suggestions as to their species.

(7.) A small specimen of *Retaster*, from deep water off Galle, is not unlike a young example which BEDFORD has placed in the same bottle as an adult *R. cribrosus;* this species is already recorded from Ceylon. With *R. cribrosus*, BEDFORD associates *R. insignis* of SLADEN. The chorology of this species is given by its author as including "Port Jackson (*fide* BELL)." The punctuation of the sentence is faulty, but I do not delay over that, as I have to point out that I think the locality, "Port Jackson," is an error. The statement is made in a paper of mine in vol. 9 of the 'Proceedings of the Linnean Society of New South Wales,' the proofs of which were never seen by me, and which teems with misprints; *Retaster* itself is misprinted. In the British Museum there is no specimen of the species from so far south as Port Jackson, and in the report of the "Alert" collections, written while the collections of the Australian Museum were in my hands, I record specimens from Port Molle and Thursday Island (p. 134), while on p. 173 I cite the species as one limited to "inter-tropical Australia."

* I have taken the opportunity of examining the "types" of *A. velutans;* they are all immature, and are, perhaps, not members of the same species.

† Describers of young Star-fishes should have their memoirs placed in some scientific Index Expurgatorius; they take no trouble, and give much.

REPORT

ON THE

CRINOIDEA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

HERBERT C. CHADWICK,
CURATOR OF THE BIOLOGICAL STATION, PORT ERIN, ISLE OF MAN.

[WITH ONE PLATE.]

THE collection of Crinoidea obtained by Professor HERDMAN during his expedition to Ceylon, and kindly placed in my hands for examination, is a most interesting one, and makes a substantial addition to our knowledge of the Comatulid fauna of Ceylon. No less than 10 species, of which one at least appears to be new to science, are added to the list of species already known from that country, and although it is remarkable that in so large a collection no specimen of *Antedon adeonæ*, one of the first species recorded from thence, should be found, it is very satisfactory to be able to give a full description of another early, but little-known species, *A. reynaudi*.

I wish here to express my sincere thanks to Professor HERDMAN for his kindness in entrusting the collection to me, and in procuring for me copies of several important papers. For similar generous help in regard to literature I would thank also my friends Dr. W. E. HOYLE, Mr. F. W. HEADLEY, Mr. R. OKELL and Mr. C. ROEDER.

The following is a list of the stations at which Comatulidæ were obtained, arranged according to their geographical position :—

West Coast of Ceylon.

STATION I.—Five miles west and south-west of Negombo, 12 to 20 fathoms ; bottom coarse yellow sand with a few dead shells ; temperature of sea, 77·5° F.

STATION II.—From 7 to 14 miles north of Négombo, 5 miles off shore ; 8 to 9 fathoms ; bottom coarse yellow sand, shells, stones, and small coral ; temperature of sea, 77·5° F. ; specific gravity, 1·023.

STATION III.—Off Chilaw, 2½ to 4 miles off shore; 9 to 14 fathoms; bottom coarse sand and small corals; temperature of sea, 77·75° F.; specific gravity, 1·023.

STATION XLVI.—From off Mount Lavinia northwards to off Colombo, from 7 to 12 miles off shore; depth 25 to 30 fathoms; bottom Nullipore balls (*Lithothamnion fruticulosum*), Coral fragments and some Orbitolites sand.

STATION LXVI.—From south of Donnan's Muttuvaratu Paar along the west of the northern part of Mutwal Island as far as off Mudalaikuli Paar; depth 10 to 35 fathoms; bottom Nullipore and Orbitolites sand, some red Algæ and dead Coral.

STATION LXVIII.—From off Coppeluddi southwards to Navakaddu Paar; depth 8 to 18½ fathoms; bottom Nullipores (*Lithothamnion fruticulosum*), Coral and muddy Orbitolites sand.

STATION LXIX.—On and to the east of the north end of Chilaw Paar; depth 8 to 11 fathoms; bottom yellow quartz sand, with some Coral fragments. Yellow Algæ with Oyster spat.

Gulf of Manaar.

STATION IX.—On south-west corner of West Cheval Paar, about 12 miles from land; depth 7 fathoms; bottom fine quartz gravel, Nullipore concretions and many dead young pearl oyster shells; temperature of sea, 78° F.; specific gravity, 1·023.

STATION LIII.—Ten to 12 miles north of Cheval Paar and about 12 miles due west of Vankali (or Bangalli) Church; depth 7½ to 9 fathoms; bottom muddy sand with some dead shells.

STATION LIV.—In northern part of Gulf of Manaar, south of Adam's Bridge; depth from 4 to 40 fathoms; bottom varied, from sand to living Coral.

STATION LVII.—Outside Dutch Moderagam Paar; 11½ to 36 fathoms; bottom Orbitolites sand, Nullipores and dead Corals.

STATION LXIII.—To the west of Periya Paar, going south; depths 17 to 55 fathoms; bottom Orbitolites sand, some dead Coral, shells and pieces of Nullipore.

Off Trincomalee.

STATION XXIII.—Close to Swami Rock, Back Bay; depth 4½ to 8 fathoms, mostly between 5 and 6 fathoms; bottom sand, shells, and in places stones and Corals.

STATION XXIV.—Two and a half to 3 miles north of Foul Point; depth ranging from 46 to 24 fathoms; bottom hard and rough—probably rock.

STATION XXV.—Three-quarters of a mile to 1 mile west north-west of Foul Point; depth 8 fathoms; bottom firm, Orbitolites sand and Nullipores.

South Coast of Ceylon.

STATION XXXIV.—Welligam Bay, various parts; depths 2 to 7 fathoms; bottom shell sand and a little mud; sea temperature at 7 A.M., 77·8° F., specific gravity, 1·0225.

STATION XXXIX.—From 2 miles south of Point de Galle westwards to Gallehogalle Bank; depths 16 to 30 fathoms; bottom fine sand; stones and Nullipore on the bank.

STATION XLI.—South of Galle, about 12 miles off land; depth along the 100-fathom line; bottom composed of masses of calcareous branched and ramifying Foraminiferal tubes.

List of Ceylon Comatulidæ.

The species marked with an asterisk were collected by Professor Herdman and were not previously known from Ceylon. The species new to science is indicated by a dagger. *Antedon carinata* and *A. reynaudi* are the only species in the collection previously recorded from Ceylon.

*	*Antedon serripinna*, Carpenter.	
*	,, *milberti* (Müller).	
	,, *carinata* (Lamarck).	
	,, *adeonæ* (Lamarck).	
*	,, *marginata*, Carpenter.	
*	,, *indica*, Smith.	
*	,, *bella*, Hartlaub.	
†	,, *okelli*, n. sp.	
	Antedon palmata (Müller).	
	,, *reynaudi* (Müller).	
*	,, *anceps*, Carpenter.	
*	,, *variipinna*, Carpenter.	
	Actinometra cumingi (Müller).	
*	,, *notata*, Carpenter.	
*	,, *multiradiata* (Linn.).	
	,, *parvicirra* (Müller).	

CRINOIDEA.

COMATULIDÆ.

Antedon serripinna, Carpenter.—Plate, figs. 1, 2, 2A.

The type specimen of this species described by P. H. Carpenter has only 12 marginal cirri, in which the number of joints is 18, while the specimens described by Hartlaub have 20 cirri, consisting of 20 joints. The specimens in this collection from Ceylon have 15 cirri, consisting of 17 joints, of which all from the second to the antepenultimate have a strong transverse dorsal ridge. This is near the distal end in the first few joints, but becomes median and, viewed in profile, spine-like in the later ones. The penultimate joint has a strong opposing spine (Plate, figs. 2, 2A). The arms of the Ceylon specimens are slender and serrate, and contain about 150 joints. The 2nd and 3rd syzygies are situated in the 8th and 12th

brachials respectively, as in the specimens described by HARTLAUB, but in the type the 2nd syzygy is between the 11th and 15th brachials. In the specimens under notice, the succeeding syzygies occur in every 5th to 7th joint. The pinnule of the 2nd brachial (Plate, fig. 1) has 11 joints, the first 3 broad, the remaining ones cylindrical, twice as long as broad, and having 2 very minute spines projecting from their distal ends. The pinnule of the 4th brachial is stouter than, and nearly twice as long as that of the 2nd, and has 13 joints of very similar character; while that of the 6th brachial has 9 or 10 joints, and is a smaller pinnule than that of the 2nd. The pinnules of the 3rd, 5th, and 7th brachials are smaller than those of the 2nd, 4th, and 6th, but the joints are similar, as are those of the next 10 or 12 pairs, though in the latter the basal ones differ in diameter less markedly from their successors.

Localities:—Stations XXIII., XXIV., and XXV., off Trincomalee: a number of more or less mutilated specimens. Many greyish mottled ones were found upon a large colony of *Gorgonia* (*Rhipidogorgia*) *flabellum* from Station XXIII.

Antedon milberti (MÜLLER).

A small specimen of this species was obtained at Station I., and 2 full-grown ones at Station LVII. In one of the arms of one of these, unfortunately detached when found, the 5th brachial beyond the 3rd syzygy is an axillary, and there is a syzygy in each of the 3rd brachials beyond it.

Antedon carinata (LAMARCK).

One specimen of this widely distributed species was dredged at Station LIV., and several mutilated ones at Station LXVIII.

Antedon marginata, CARPENTER.

One considerably mutilated specimen of this species was dredged at Station XXXIX. It has 11 arms, and most of the 2nd pinnules agree well with those of the single specimen dredged by the "Challenger" at Station 208, off Manilla, which CARPENTER says "Terminate so abruptly that they seem to have been broken off by some accident and not completely repaired. The diameter of the joints suddenly decreases, and there are from 1 to 4 quite small joints at the end of a large and stout one which is considerably longer than wide." A small specimen from Welligam Bay (Station XXXIV.) may possibly belong to this species. The number of arms cannot be determined, but in one of the rays the outer face of the distichal axillary bears two palmars.

Antedon indica, SMITH.

One specimen of this species, with 29 arms, was dredged at Station LIV. The original visceral mass is almost completely displaced, but remains in organic continuity with a new one in an early stage of formation.

Antedon bella, HARTLAUB.

Specimens of this beautiful species were dredged at Stations LIII. and LVII. One of those from the first-named station has 28 arms, and the other, now much mutilated, must have had the same number when living, palmars being present on the outer side of both distichal series in three of the rays. The specimens from Station LVII. agree with the type in possessing 20 arms. A specimen of what appears to be HARTLAUB'S variety *brunnea* was obtained at the last-named station.

Antedon okelli, n. sp.—Plate, figs. 3 to 5.

Centro-dorsal a moderately thick, roughly circular disk, with flat or very slightly convex dorsal surface, and bearing upon its sloping sides 20 to 25 cirri. These have 25 to 28 joints, of which the more distal ones are compressed and carinate, and the penultimate bears an opposing spine (Plate, fig. 4). First radials distinctly visible; the 2nd broad, well rounded, and forming a tubercular elevation in their median line of junction with the axillaries, which are broadly pentagonal and about $1\frac{1}{2}$ times the length of the 2nd radials (Plate, fig. 3). Two distichals and 2 palmars, the axillaries without syzygy. The palmars are borne upon the outer face of the distichal axillaries of one or both sides of the ray, generally the latter. Median tubercles formed by both distichals and palmars. The rays have slight marginal projections. Twenty-six to 30 arms, of about 120 joints, of which the first 7 or 8 are moderately thick disks. These are followed by rather more than 20 triangular joints, and these again by wedge-shaped ones, which become longer in proportion to their width as the tip of the arm is reached. Syzygies in the 3rd, 13th or 14th, 20th or 21st joints, and then every seventh or eighth joint.

Of the first pair of pinnules, that borne by the 2nd brachial on the outer side of the ray has 18 to 20 joints, of which only a few of the more distal ones are longer than wide (Plate, fig. 5). Its fellow on the 3rd brachial is smaller and more slender, and has 16 or 17 joints. The pinnule of the 4th brachial has 20 to 22, or even 24 joints. It is considerably stouter and longer than that of the 2nd, and its joints diminish in size more gradually; while that of the 5th brachial has 19 or 20 joints, but in all other respects is precisely like that of the 4th. The 3rd pair of pinnules, borne by the 6th and 7th brachials respectively, are smaller than the 1st, and have 14 to 16 joints. The basal joints of all these pinnules and of the 3 or 4 succeeding pairs are distinctly carinate, the latter especially so. The corresponding pinnules on the inner arms of the rays are a little smaller and have slightly fewer joints.

Colour in spirit—creamy white, mottled and striped with deep reddish-brown. Margins of bases of rays and long tubular anal funnel with spots of same colour (Station I.). These are described as "black and white" when living. Others ashy or purplish-grey to deep purple, almost black. In the paler specimens the skeletal joints are marked with narrow bands of deep purple, and the disk has spots of the same colour. Sacculi abundant on pinnules, less so on disk.

Disk, 1 centim., deeply incised; spread, 10 centims.

Locality:—Stations I., II., and LVII. Twenty-two specimens, of which 12 were from Station II.

This species is closely allied to *Antedon brevicuneata*, CARP., *Antedon similis*, CARP., and *Antedon regalis*, CARP. It differs, however, from each of them in having all 3 radials visible, a much smaller number of cirri, shorter arms, and carinate basal joints on the lower pinnules.

I have associated this species with the name of Mr. ROBERT OKELL, B.A., F.L.S., Hon. Secretary of the Isle of Man Sea-Fish Hatchery Committee, to whom I am indebted for much kind help with the literature of the subject.

Antedon reynaudi (MÜLLER)—Plate, figs. 6 to 12.

As this species was very briefly described by MÜLLER, and is still very imperfectly known, I have thought it useful to give the following full description of the Ceylon specimen, accompanied by the necessary figures.

Description of an Individual.—Centro-dorsal a thick disk, with convex dorsal surface, and bearing on its sloping sides, in two alternating rows, 25 cirri. Of these all but a few immature ones are rather more than 2 centims. long, and have 35 or 36 joints, all of which are slightly wider than long, the later ones being laterally compressed, and bearing, from the 14th onwards, a strong and forwardly directed spine (Plate, fig. 8).

First radials entirely concealed; the 2nd just visible beneath the bases of the cirri, and in almost complete contact laterally. Axillaries widely pentagonal, about half as long again as the 2nd radials and without syzygy. Eighteen arms of about 200 short and slightly overlapping joints (fig. 12). The 1st distichals are in almost complete contact laterally, and form a slight tubercular elevation in their median line of junction with the second. The first 8 brachials are discoid, the two 1st in almost complete contact laterally, and are succeeded by about 30 shortly triangular joints. These again are followed by discoid ones which continue to the tip of the arm.

Two of the rays have each two series of 3 distichals (fig. 7), the axillaries having a syzygy; other two have each (fig. 6) one series of 3 distichals, the axillaries having a syzygy, and one series of brachials arising directly from the radial axillary. The remaining ray has two series of 2 distichals, the axillaries having no syzygy. The position of the brachials in which syzygies occur is very irregular, as shown by their enumeration in 6 series, as follows:—

(1.)	Brachials,	3, 12, 19, 25, 33, 42, 50, 58, 66.
(2.)	,,	3, 8, 12, 18, 25, 28, 35, 42, 55, 63, 67, 73, 80.
(3.)	,,	3, 14, 23, 31, 38.
(4.)	,,	3, 14, 23, 32, 46, 55.
(5.)	,,	3, 15, 21, 28, 34.
(6.)	,,	3, 6, 29.

The distichal pinnule (fig. 9) is about 1 centim. long, flagellate, and composed of 31 joints, the first 7 broad, flattened, and carinate, the later ones gradually becoming cylindrical, longer than broad and with rounded ends. The 1st and 3rd pairs of brachial pinnules are about equal in size, those borne by the 2nd and 6th brachials (fig. 11) having about 29 joints. The 2nd pair of pinnules are the largest on the arm, that of the 4th brachial (fig. 10) being about 15 millims. long, but having 27 joints only. The basal joints of these 3 pairs of pinnules are flattened and more or less carinate. The 5th pair are the shortest, the succeeding one gradually increasing in length. Disk considerably incised and ambulacra naked. Sacculi abundant and close-set on arms and pinnules, absent on disk.

Colour in spirit—disk chocolate-brown, fading to white in the interambulacral angles; arm joints pinkish, with the articulations of the proximal fourth marked with bands of deep reddish-brown, which gradually fade into dots on the sides of the arms. Pinnules irregularly banded with brown and white.

Disk 1 centim., spread probably 22 centims.

Locality:—Station XXXIV.

It is to be regretted that strong reflexion of the arms over the dorsal surface of the disk in the only specimen obtained has made delineation of the skeleton rather difficult. The bidistichate ray is not improbably an abnormality.

Antedon anceps, CARPENTER.

Two specimens of this species were dredged, one at Station XXIV., and the other at Station LVII. Both have a single distichal series and 11 arms. The colour, when living, was black.

Antedon variipinna, CARPENTER.

A considerable number of specimens of this remarkable species were dredged at Station II. They have 20 to 21 fairly smooth arms, 30 to 36 cirrus joints, the later ones carinate, and the 1st radials are only visible in side view.

Actinometra notata, CARPENTER.

One specimen of this species was obtained at Station LIV. CARPENTER's diagnosis assigns to it 30 to 35 cirri and 31 to 50 arms, but the specimen under notice has only 20 cirri, 8 of which are quite small and immature, and 20 arms. The 1st radials are distinctly visible and almost completely united laterally. They are also connected with the centro-dorsal by five interradial projections from the latter.

Actinometra multiradiata (LINN.).

Single specimens of this species were dredged at Stations IX., XLI., LIII., and LXVI. That from the first-named station has 12 arms only. Two of the rays have each a series of 3 distichals, the axillary with a syzygy, and a syzygy in each of the 2nd brachials; but in all the arms which arise directly from the radial

axillaries the 1st syzygy is in the 3rd brachial. The diameter of the 22 arms of the specimen from Station LXVI. gradually increases from the 1st to about the 20th brachial.

Actinometra parvicirra (MÜLLER)—Plate, figs. 13, 14.

Specimens of this well-known species were dredged at Stations IX., XLI., XLVI., LIV., LVII., LXIII., and LXIX. The number of arms varies from 10 in a specimen from Station XLI. and 11 in one from Station LVII. to 48 in one from Station IX. So far as I am aware, no 10-armed specimen of this species has hitherto been discovered; and as the form and disposition of the 2nd and 3rd radials of the one under notice differ markedly from the same parts in the other specimens in the collection and from those figured in CARPENTER'S Report on the Comatulidæ of the "Challenger" Expedition, I have thought it worthy of illustration (fig. 13). It will be seen that the disk is covered with minute scale-like plates (fig. 14), which, I presume, are similar to those covering the disk of the specimen from Torres Straits, mentioned by CARPENTER. The specimens with 44 and 48 arms respectively approach *Actinometra regalis*, CARP., in having no spines, or but feebly developed ones, on the penultimate joints of the cirri, and in the close lateral contact of the 2nd and 3rd radials and 1st distichals. Several distichal series consisting of two joints occur in most of the specimens. The colour of one of the specimens from Station LXIX. is described in Professor HERDMAN'S diary as being, when living, "of a deep olive-brown with yellow tips to the pinnules, and having an olive-brown species of *Alphæus* striped with grey living on it." Some of those from Station XLVI. were "dark purple," others "orange coloured."

DESCRIPTION OF PLATE.

Fig. 1. Base of an arm of *Antedon serripinna*, with pinnules of 2nd, 4th, 6th, and 8th brachials. × 10.

,, 2. A cirrus of *Antedon serripinna*. × 10.

,, 2*a*. Portion of same, viewed from the dorsal surface. × 10.

,, 3. *Antedon okelli*, n. sp. × 4.

,, 4. A cirrus of *Antedon okelli*. × 8.

,, 5. Base of an arm of *Antedon okelli*, with pinnules of 2nd, 4th, 6th, 8th, and 10th brachials. × 10.

,, 6. A ray of *Antedon reynaudi*, with one series of distichals and an arm springing directly from the radial axillary. × 5.

,, 7. A ray of *Antedon reynaudi*, with two series of distichals. × 5.

,, 8. A cirrus of *Antedon reynaudi*. × 5.

,, 9. Distichal pinnule of *Antedon reynaudi*. × 5.

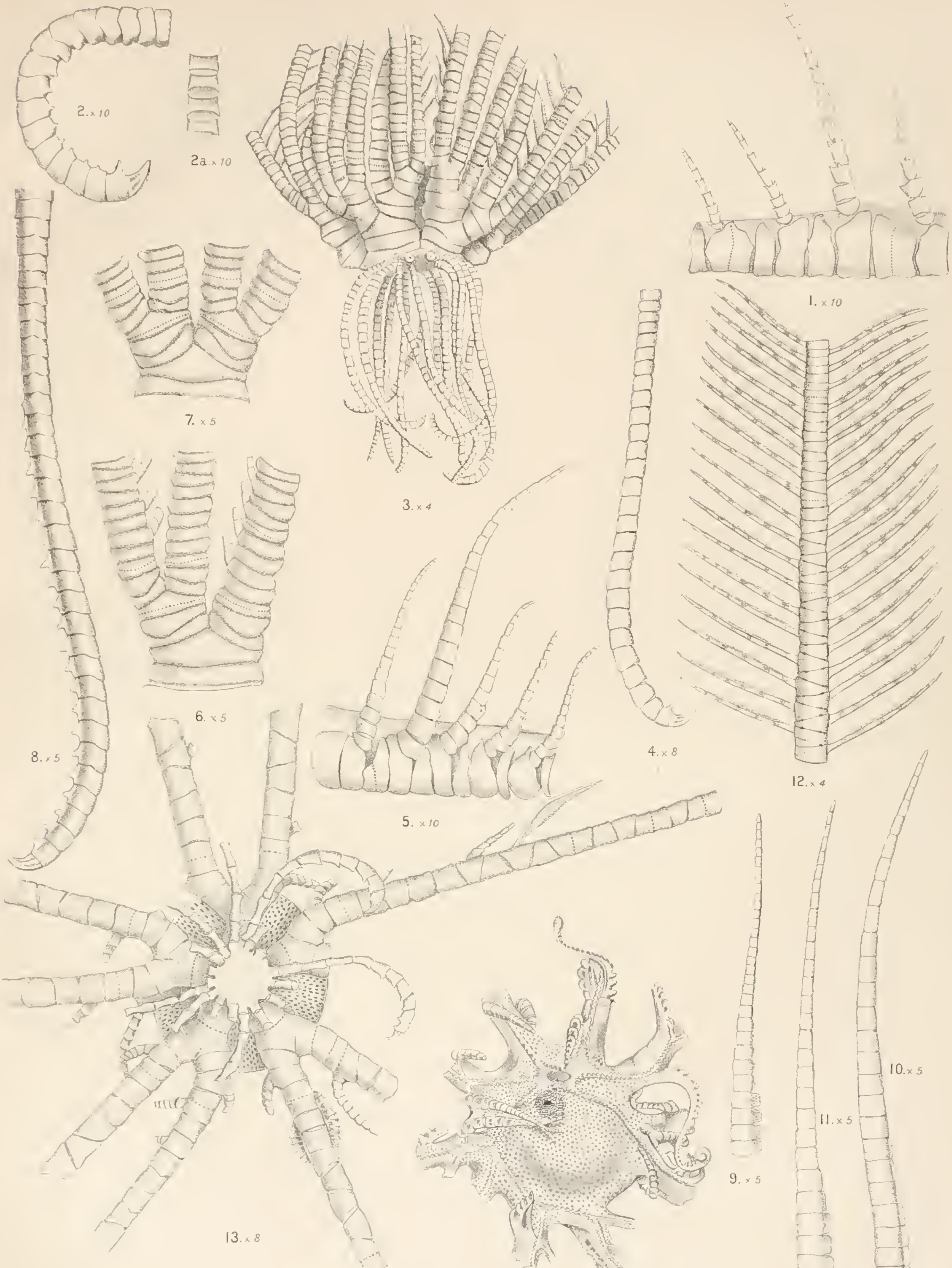
,, 10. Pinnule of 4th brachial of *Antedon reynaudi*. × 5.

,, 11. Pinnule of 6th brachial of *Antedon reynaudi*. × 5.

,, 12. Portion of an arm of *Antedon reynaudi*, viewed from the dorsal surface. × 4.

,, 13. A 10-armed specimen of *Actinometra parvicirra*, viewed from the dorsal surface. × 8.

,, 14. Disk of the same specimen, viewed from the ventral surface. × 8.



H C C del. Edwin Wilson, Cambridge

FIGS. 1, 2, ANTEDON SERRIPINNA. FIGS. 3-5, ANTEDON OKELLI.
FIGS. 6-12, ANTEDON REYNAUDI. FIGS. 13, 14 ACTINOMETRA PARVICIRRA.

REPORT

ON THE

CUMACEA

COLLECTED BY

Professor HERDMAN, at CEYLON, in 1902.

BY

W. T. CALMAN, D.Sc.

[With PLATES I. to V.]

This paper deals with the Crustacea belonging to the Order Cumacea* collected in Ceylon by Professor W. A. Herdman, F.R.S., and his Assistant, Mr. Hornell. The following ten species are described in detail, and all of these are regarded as new except one :—

1. *Eocuma taprobanica*, n. sp.
2. *Eocuma affinis*, n. sp.
3. *Eocuma sarsii* (Kossmann).
4. *Cyclaspis costata*, n. sp.
5. *Cyclaspis picta*, n. sp.
6. *Cyclaspis herdmani*, n. sp.
7. *Cyclaspis hornelli*, n. sp.
8. *Iphinoë macrobrachium*, n. sp.
9. *Paradiastylis brachyura*, n. sp.
10. *Nannastacus stebbingi*, n. sp.

In addition to these the collection includes the following six species which are not dealt with more fully here for the reason that they are represented by solitary or immature specimens, or that they belong to species of which more abundant material is at hand in other collections now in course of examination. The list is given in order to complete, as far as possible, the record of the Ceylon fauna as shown by the present collection :—

* Mr. Stebbing has shown (Willey's 'Zool. Results,' Part V., Crustacea, p. 609) that the generic name *Cuma*, H. Milne-Edwards, is preoccupied and must give way to *Bodotria*, Goodsir, and he has proposed to change the name of the order to Sympoda. So far as I am aware, no rule of zoological nomenclature is infringed by retaining the familiar name Cumacea, which may still be thought not "wholly inappropriate and misleading" for an order comprising many genera with names like *Pseudocuma*, *Leptocuma*, *Eocuma* and so forth.

(1.) *Eocuma* sp.—Taken in the tow-net in Galle Bay after dark. A young and damaged specimen, apparently distinct from any of the species described below.

(2.) Bodotriidæ, n. gen. and sp.—Gulf of Manaar, near the shoal buoy, north of Karativo Island. A very young specimen belonging to an undescribed species (representing a new genus), of which a large series of specimens from the Gulf of Siam is in the collection of the Copenhagen Museum.

(3.) *Cyclaspis* sp.—From the Cheval Paar and Kondatchi Paar. Two young specimens of a species which is also represented in the Copenhagen collection from Siam.

(4.) *Cumopsis* (?) spp.—Several immature specimens from various localities on the Cheval Paar, and off Chilavaturai, in the Gulf of Manaar.

(5.) *Cumella* sp.—From the Cheval Paar and near the shoal buoy north of Karativo Island.

(6.) *Nannastacus* sp.—From the Cheval Paar, and $2\frac{3}{4}$ miles south-south-west of Chilavaturai, in the Gulf of Manaar.

The great majority of the species of Cumacea hitherto described are inhabitants of northern seas, and only a very few (some 13 out of a total of about 170 species) have been found within the tropics. It can hardly be doubted, however, that, as in the case of other groups of micro-crustacea, this preponderance of northern species is more apparent than real, and is due to the fact that collectors in tropical countries have their attention claimed by the more conspicuous elements of the fauna to the exclusion of the more minute and less obtrusive forms. No Cumacea have hitherto been recorded from any part of the Indian Ocean, although four species have been described by Paulson and by Kossmann from the Red Sea, and one of these is represented in the present collection.

The types of the species described below have been presented by Professor Herdman to the British Museum (Natural History).

Family: BODOTRIIDÆ.

Eocuma, Marcusen.

Marcusen, 'S.-B. Ges. naturf. Fr.,' Berlin, 1894, p. 170; Hilgendorf, *Tom. cit.*, p. 171; Zimmer, 'Zool. Jahrb.,' Syst. XVIII., p. 669, 1903.

Carapace sub-globular or more or less flattened dorso-ventrally, having a pair of procurved lateral cornua, behind which the lateral margin is usually sharply keeled. Four thoracic somites are free behind the carapace. First pair of legs having the basis produced distally into a pointed lobe on the upper (or inner) side of the articulation of the ischium. Second legs generally very short, composed of six

segments, the ischium being suppressed. Uropods having the peduncle shorter than the rami.

The genus *Eocuma* was established by MARCUSEN in 1894 for the reception of a Japanese species, to which he gave the name *E. hilgendorfi*. The paper was published after the death of the author, with some additional notes by HILGENDORF, and was not accompanied by any figures. Recently the species has been re-described and figured by ZIMMER from two of HILGENDORF'S specimens, the actual type specimens having been lost. In the original description the chief characters given as distinctive of the genus are the flattened form of the carapace and the meeting in the middle line of the basal segments of the first pair of legs. The last-named character does not hold good, as ZIMMER has shown, for the sub-adult female, while on the other hand I find it in immature specimens of several other genera. The flattening of the carapace is much less marked in the adult male than in the female in the species described below as *E. taprobanica*, and it is clearly impossible to base the genus on this character alone. I propose therefore to modify the generic definition so as to include all those species of Bodotriidæ in which the carapace bears a pair of curved lateral horns. In this way we obtain the following assemblage of species which appears to be a natural one, the various forms agreeing also in the above-mentioned characters of the first and second legs and of the uropods :—

Eocuma hilgendorfi, MARCUSEN, 1894. Type of the genus.
E. ferox (FISCHER) = *Bodotria ferox*, FISCHER, 1872 = *Cyclaspis cornigera*, G. O. SARS, 1879 = *Cyclaspoides ferox*, BONNIER, 1896.
E. sarsii (KOSSMANN) = *Cyclaspis sarsii*, KOSSMANN, re-described below.
E. taprobanica, n. sp.
E. affinis, n. sp.

The genus *Cyclaspoides* of BONNIER ('Ann. Univ., Lyon,' 1896, "Campagne du 'Caudan,' Édriophthalmes," p. 530) is distinguished from *Cyclaspis* only by the fact that the second legs are composed of six instead of seven segments. Of the two species referred to it, *C. sarsii*, BONNIER, and *C. ferox* (FISCHER), neither is explicitly named as the type of the genus. *C. sarsii*, however, differs in so many particulars from *C. ferox* that it may conveniently be left in a different genus, for which the name *Cyclaspoides* may be retained.

The distinguishing characters of the species here referred to *Eocuma* may be summarised as follows :—

A. Lateral margins of carapace carinated.
  1. Pseudorostrum reaching forwards beyond the level of the lateral cornua. Carapace much depressed, surface smooth.
    a. Antero-lateral tooth on either side of pseudorostrum inconspicuous (♀) or absent (♂). No paired ridges on dorsal surface of carapace. *E. taprobanica.*

b. Antero-lateral teeth very prominent, reaching as far forward as pseudorostrum, from which they are separated only by a shallow concavity on each side. Dorsal surface of carapace with a longitudinal ridge on the branchial region on each side. *E. hilgendorfi.*

2. Pseudorostrum not projecting beyond tips of lateral cornua, squarely truncate. Antero-lateral teeth well defined. Carapace somewhat inflated, surface rough and uneven. *E. sarsii.*

B. Lateral margins of carapace rounded.

1. Carapace (of male) about one-fourth of total length and one-fifth longer than broad. *E. ferox.*

2. Carapace (of male) about one-third of total length, nearly twice as long as broad. *E. affinis.*

Eocuma taprobanica, n. sp.—Plate I., figs. 1 to 20 ; Plate II., figs. 21 to 28.

Description of *Female*, sub-adult, with developing oostegites. Total length,* 11·1 millims. (figs. 1, 2, 6) :—

The carapace is about two-sevenths of the total length, very broad and flattened, with a well-marked lateral carina on each side. The greatest width is about five-sixths of the length, and is at a distance of less than one-third of the length of the carapace from the front, where are situated the incurved lateral cornua. Behind this the slightly convex sides converge towards the hind margin, where the width is about one-half of that measured across the cornua. The pseudorostrum is prominent, and the tip, as seen from above, is broadly notched. External to it on each side the antero-lateral margin forms a blunt tooth, between which and the lateral cornu the outline is again slightly convex. The dorsal surface, which is slightly arched from before backwards and more strongly so from side to side, presents a faintly marked median keel, becoming more distinct anteriorly, where there is a shallow depression on either side of the cephalic lobe. The sides of the carapace are sharply inflected at the lateral edge, so that the under surface is nearly flat. A transverse ridge runs from each of the lateral cornua to the lower or free margin of the carapace on the under side. The hinder edge, seen from the side, slopes backwards, forming an oblique angle with the lower and with the lateral margins, which meet at its lower end. The ocular lobe is slightly broader than long, and the pseudorostral plates meet in front of it for a distance equal to its width. The eye is not pigmented in the specimens examined ; there are three corneal facets, large in size, but indistinctly defined. The surface of the carapace presents a faint and inconspicuous pitting which does not interrupt the minute and regularly reticulate texture of the exo-skeleton.

The transverse width of the thoracic somites diminishes regularly, tapering down

* The "total length" given in each case excludes the uropods.

to the slender abdomen. The first leg-bearing somite is not distinct, though a rather faint line which marks off a narrow, diamond-shaped area from the hinder part of the carapace above may (as ZIMMER has suggested in *E. hilgendorfi*) represent its line of fusion with the carapace. The second somite also appears to be firmly united to the carapace. The third and fourth somites are reduced above to narrow transverse bars, connected with each other by wide spaces of articular membrane, so that this region of the body is very mobile and is usually strongly flexed dorsally, the dorsal portion of the third somite being quite concealed beneath the second.

The abdomen is very slender, longer by one-fifth than the cephalothoracic region. The somites, which are sub-cylindrical, with a slight median dorsal keel, diminish a little in width, so that the fifth, which is the longest, is also the narrowest, being nearly four times as long as broad. The last somite is a little depressed and broadened posteriorly. In the lateral articulations of the somites the anterior articular process of each is met by and overlaps a single process from the somite in front, instead of engaging in a notch as in most species of *Cyclaspis*.

The antennules (fig. 7) have the basal segment large and of peculiar form. Its distal half is bent at an angle to the proximal part and is flattened and triangular in form, very broad at the base, and narrowing distally to the articulation of the second segment. In the natural position of the parts this triangular portion appears to be firmly fixed in a notch in the free edge of the carapace, corresponding, no doubt, to the "antennal notch" in more normal Cumacea, but in the present case, owing to the flattening of the carapace, carried round to the under surface and quite invisible from the side or from above. The second and third segments of the antennular peduncle are slender, the third half as long again as the second. The external flagellum is about half the length of the last peduncular segment and is composed of two sub-equal segments. The internal flagellum is quite rudimentary and exceedingly minute.

The antenna (fig. 7) is a simple rounded nodule bearing two plumose setæ. No trace could be discovered of the narrow terminal segment generally present in allied genera.

The mandibles (fig. 10) are of the normal type, and carry a row of about 13 spines.

The lower lip (fig. 11) has broadly rounded lobes, clothed with fine setæ.

The maxillulæ (fig. 12) have a slender palp longer by one-half than the distance between its base and the tip of the distal lobe, and carrying two apical setæ.

The maxillæ are of normal structure.

The first maxillipeds (fig. 13) have the basis very broad and shorter than the rest of the limb. The branchial apparatus is remarkably well developed. Its posterior division (epipod) is produced forwards as a rounded lobe which reaches as far as the end of the basis. The branchial lobules are broad, lamellar, and about 22 in number. A reflexed anterior lobule could not be discovered. In the anterior division (exopod

of SARS) the oval chitinous plate, which forms a valve-like lid to the respiratory aperture, is well defined.

The second maxillipeds (fig. 15) have the basis sub-equal in length to the remaining segments together. The ischium, which is not distinct in most species of *Cyclaspis*, is here well defined though small.

The third maxillipeds (figs. 16, 16A) are expanded, and are opercular in function, serving along with the basal segments of the first legs to completely cover in the other mouth parts. The basis is in the natural position of the parts partly covered by the basis of the first leg, and its distal part, which is exposed, is more strongly calcified and sharply defined from the concealed proximal part. At its distal end the segment is produced into a long and narrow curved process reaching nearly to the end of the merus. The ischium, unlike that of *Cyclaspis*, is very broad, not narrower than the succeeding segment. The three distal segments are comparatively slender.

The first legs (fig. 21) are long, extending beyond the pseudorostrum by nearly the length of the last two segments. The basis is very broad and flattened, narrowing suddenly at about its distal third and produced beyond and (in the natural position) above the articulation of the next segment into a sharply pointed process which extends beyond the distal end of the ischium. The rest of the limb is slender, and the last three segments are much elongated, the carpus and the propodus sub-equal and a little longer than the dactylus.

The second legs (fig. 17) are much shorter than the succeeding pairs and have a peculiar form. The basis is about equal to the remaining segments together. The ischium is suppressed. The merus is very short, but is produced distally on the inner side and bears a stout spine which reaches almost to the end of the limb. The next two segments are short and sub-equal, and together equal in length to the terminal segment, which bears three apical setæ and one lateral.

The fourth legs are slightly longer than either the third or the fifth (figs. 18 to 20). In each the basis bears several long setæ, and the terminal segment is very short, with a rather stout claw.

The uropods (fig. 27) are rather less than one and a-half times the length of the terminal somite. The peduncle is about two-fifths of the length of the sub-equal rami. The endopod bears a few spinules and plumose setæ on its inner edge. The outer edge of the exopod is obscurely serrate, its inner edge unarmed. The apices of both rami (fig. 27, A, B) have a rather peculiar structure. The endopod tapers down to a minute rounded knob, beyond which projects a flattened or rather winged spine consisting of a central rachis with a striated wing or web running down either side. The tip of the exopod is bifid, the two points close together, the lower having the same structure as the tip of the endopod, the upper differing in being without the knob-like process.

Adult *Male*, 9·3 millims. in length (figs. 3, 4) :—

Carapace much narrower than in the female, its greatest width about five-ninths of

its length. Lateral cornua less prominent, directed forwards. Antero-lateral margins between pseudorostrum and lateral cornua simply convex with hardly an indication of the antero-lateral tooth. The lateral keel is well marked, as is also the transverse ridge running inwards from the lateral cornu on the lower surface. The median ridge is more distinct on the posterior part of the dorsal surface. The ocular lobe nearly twice as broad as long, the corneal areas much larger and more distinct than in the female. Anterior abdominal somites hardly narrower and somewhat deeper than posterior thoracic; sixth abdominal somite narrowing suddenly about the middle of its length.

Antennule (fig. 8) having three segments in the outer flagellum.

Antenna (fig. 9) of normal type, its flagellum about as long as the body. First two segments of peduncle bearing each a plumose seta.

Branchial apparatus (fig. 14) more fully developed than in the female, the laminæ much longer and 33 in number.

First leg (fig. 22) a little shorter than that of the female, the basis longer and narrower and having a group of spines on its lower surface near the inner edge.

Second leg (fig. 23) closely resembling that of female, except that the ischium is a little longer. The remaining legs (figs. 24 to 26) stouter than in the female and having more numerous and longer plumose setæ on the proximal segments.

Uropods (fig. 28) differing from those of the female in having the inner edges of the peduncle and endopod densely set with plumose setæ and in having a few setæ on the outer edge of the exopod.

Young Specimen, 4·8 millims. in length :—

The outline of the carapace (fig. 5) differs considerably from that of the adults. The lateral margins behind the cornua are nearly straight, the pseudorostral lobes are relatively much broader, the antero-lateral tooth is more prominent and more angular, and that portion of the antero-lateral margin lying between the tooth and the lateral cornu is straight instead of convex as in the female.

Localities.—Many specimens from the Gulf of Manaar, on the Cheval Paar, depth 6 to 7 fathoms; and on the Periya Paar Kerrai, depth 8 to 9 fathoms.

Eocuma affinis, n. sp.—Plate II., figs. 29 to 34.

Description of adult *Male*, 6·7 millims. in length :—

Differing from the last species in the narrower and less depressed form of the carapace, which is about three-tenths of the total length and evenly rounded at the sides without any lateral keels. Seen from above, the sides are nearly parallel, and the greatest width is little more than half of the length. The cornua are rather prominent, curved, and directed forwards. In front, the antero-lateral margin is finely serrate. On the dorsal surface a transverse depression crosses the hinder part of the cephalic lobe. The pitting of the surface of the carapace (fig. 31) is more marked than in the last species and the minute reticular texture is less distinct.

A minute granule is set in the centre of each pit, and between the pits are scattered here and there small tubercular elevations.

The first legs (fig. 32) have the basis narrower than in the last species, and the spines on its lower surface more numerous. The dactylus is only half the length of the preceding segment.

The second legs (fig. 33) have the basis very short, only one-third of the whole length of the limb. The spine on the ischium only reaches to the end ot the succeeding segment.

The uropods (fig. 34) are nearly twice as long as the terminal somite, the peduncle nearly one-third of the length of the rami. The inner edges of peduncle and endopod clothed with setæ, among which are one or two spinules. The outer and inner edges of the exopod each bear a number of setæ.

Locality.—The Cheval Paar, in the Gulf of Manaar, depth 7 fathoms. Two specimens.

Eocuma sarsii (Kossmann)—Plate II., figs. 35 to 38.

Cyclaspis sarsii, Kossmann, 'Zool. Ergeb. einer Reise in die Küstengebiete des rothen Meeres,' II., 1te Lief., III., Malacostraca (2. Theil; Anomura), pp. 88 to 90, Plate IV., fig. 3, 1880.

A single immature specimen, 4 millims. in length, probably female, which I refer to this species, has the following characters: Carapace hardly depressed, about five-sixteenths of total length, with very stout curved lateral cornua, behind which the lateral margin is marked by a low irregularly serrate ridge. The breadth across the cornua is four-fifths of the length. The cornua reach forward as far as the level of the pseudorostrum, which is broad and squarely truncate, as seen from above. External to the pseudorostrum on each side is an almost rectangular tooth, the anterior edge of which is serrate. This tooth is separated from the lateral cornu by a deep semicircular excavation. The dorsal surface is raised into a median keel anteriorly, where also there is a slight elevation on each side of the cephalic lobe. At its anterior end the median keel bifurcates on the ocular lobe to separate from each other the three not very distinct corneal areas. About the middle of the length of the carapace the median keel dies out and is replaced by a pair of longitudinal ridges some distance apart. The hinder margin of the carapace is elevated in the middle line into a rounded tubercle. The ocular lobe is nearly twice as broad as long, and there is no ocular pigment. The pseudorostral plates meet in front for a distance about equal to the length of the ocular lobe. Seen from the side, the pseudorostrum is obliquely truncated. The surface of the carapace (and, less distinctly, the rest of the exoskeleton) is covered with shallow circular pits, in the centre of each of which is a minute granule. The surface between the pits forms a raised network, which shows more or less distinctly the primary reticular texture of

the exoskeleton, and is here and there raised into tubercles, giving the whole surface a rough and uneven aspect (fig. 37).

The first leg-bearing somite is not exposed. The second is much lower than the hind margin of the carapace. The remaining thoracic somites diminish gradually in width ; a pair of tubercles is present on the dorsal surface of each of the two last.

The abdomen is stout, but on account of an injury to the posterior somites the relative length of this region cannot be stated. All the somites, including the two last, have a prominent median dorsal keel. Seen from above, each of the somites is markedly constricted anteriorly, and also a little before its hinder margin. The lateral articular processes do not overlap.

The first legs are relatively short and stout, the basis not much less than half the total length of the limb.

The second legs are much shorter than the next succeeding pair. They are composed of six segments, as in the above-described species, but there is no spine developed on the merus.

The uropods (fig. 38) are short and stout, about two-thirds longer than the last somite. The peduncle is not much longer than broad, and is about two-fifths the length of the sub-equal rami. Its inner edge bears a few spinules. Both rami end in spiniform terminations marked off by indistinct suture lines, and bluntly rounded and bent outwards at the tip. A single seta accompanies the terminal spine on the exopod, which is otherwise unarmed. The endopod has a row of minute spinules on its inner edge.

Locality.—From the Cheval Paar, in the Gulf of Manaar, depth 7 fathoms.

The identity of the form here described with Kossmann's *Cyclaspis sarsii* from the Red Sea is at once suggested by its general shape, and especially by the thick clumsy form of the lateral cornua. Kossmann's figure shows the cornua as relatively smaller than in the present specimen, and the lateral margins behind them nearly straight. The paired ridges on the dorsal surface of the carapace are close together, and there are two oblique ridges on the dorsal surface of the peduncle of the uropods. It seems likely, however, that some of these differences may be due to the difference in age and in sex, Kossmann's specimen being a male, 9 millims. in length, more than twice the length of the present specimen, which is probably a young female. Kossmann's description of the sculpturing of the exoskeleton agrees exactly with that observed in this specimen.

Cyclaspis, G. O. Sars.

G. O. Sars, 'Forh. Vidensk. Selsk. Christiania,' 1864 (1865), p. 206.

The genus *Cyclaspis*, even after the removal of the species above transferred to *Eocuma*, still includes a somewhat varied assemblage of forms, and becomes increasingly difficult to define from the neighbouring genera of Bodotriidæ. Without attempting,

for the present, to frame a fresh definition, it may be pointed out that the species described below, which are referred to *Cyclaspis* on the ground of general similarity in form to species already included therein, differ from them in the fact that they possess, in the adult female at least, five distinct thoracic somites behind the carapace. Since, however, the first somite is entirely hidden in most cases in the adult male as well as in immature specimens of both sexes, it seems inadvisable to make this character the ground for separating these species generically from those in which the somite in question is concealed or suppressed in both sexes at all stages of growth.

Cyclaspis costata, n. sp.—Plate III., figs. 39 to 53.

Description of adult *Female.* Total length 3·75 millims :—

Carapace about three-eighths of total length, its vertical height nearly two-thirds of its length, compressed, the dorsal surface rounded posteriorly, but keeled in its anterior half, where there is a well-marked depression on either side of the middle line. Pseudorostrum acute, prominent and slightly upturned as seen from the side. Antennal notch shallow and widely open, the antennal tooth obtuse. Ocular lobe large, sub-circular, pseudorostral plates meeting in front of it for a distance equal to its diameter. The eye pigmented and apparently well developed. The sides of the carapace, behind and below the depressions mentioned above, are beset with longitudinal ridges formed by rows of minute granules. There are about twelve such ridges on either side in the specimen figured, with fainter secondary ridges interposed between some of them. In a larger female specimen the ridges are more numerous and closer together, owing apparently to the greater prominence of the secondary ridges.

First leg-bearing somite well exposed. Second somite produced dorsally into a median crest. Fourth and fifth having the dorsal surface raised into a rounded tubercle on each side of the middle line.

Abdomen shorter than the cephalothoracic region, the somites comparatively stout, with a faintly indicated dorsal keel, and with well-developed "peg and socket" articulations laterally.

Antennules (fig. 42) very short, first segment of peduncle much enlarged and longer than the other two segments together, outer flagellum with two segments, inner flagellum very minute.

Antennæ (fig. 43) unjointed, not produced, bearing two plumose setæ.

The mouth-parts closely resemble those of *C. australis;* the mandibles bear about 13 spines. The branchial apparatus was not examined.

The third maxillipeds (fig. 44) have the basis abruptly bent at about the middle of its length, and slightly longer than the succeeding segments together. The external process of the merus is very large, extending far beyond the process of the basis. The propodus is expanded, not much narrower than the carpus, and the dactylus is almost rudimentary.

The first legs (fig. 45) are very short, just reaching to the antennal angle of the carapace when extended forwards. The basis is about equal in length to the succeeding segments together.

The second leg (fig. 47) exhibits the full number of segments; it is short and stout, and its terminal segment is armed with three spines. The third legs are longer than the second, and the fourth and fifth successively diminish in length by shortening of the basis (figs. 49 to 51). The propodus and dactylus of these limbs are rather slender.

The uropods (fig. 52) are short and stout; the peduncle is about equal to the terminal somite in length and finely serrate on its inner margin. The rami are subequal and a little shorter than the peduncle. Each is tipped by a stout spine. The exopod is otherwise unarmed except for a small spinule implanted external to the base of the large spine. The endopod has a single spine on its inner edge near the distal end.

In addition to scattered pigment spots on the carapace and free thoracic somites, there is a more or less well-marked pigmentation of the first two and the last abdominal somites.

Adult *Male*. Total length, 3·9 millims. (fig. 41) :—

The carapace is less deep than in the female, with the dorsal outline less arched. The pseudorostrum is shorter and truncated, the plates meeting for only a short distance in front of the ocular lobe. The latter is large, inflated, with large and distinct corneal lenses. On the upper part of the side of the carapace the longitudinal ridges only occupy the posterior third, stopping short at a vertical ridge in front of which the surface is irregularly granulated.

The first leg-bearing somite is exposed dorsally and the second is not distinctly crested. The posterior thoracic somites are broad and depressed, with prominent dorso-lateral corners. The abdomen is remarkably stout, a little longer than the cephalothoracic region, the anterior somites broader and deeper than long, the fifth somite narrowing suddenly about the middle of its length.

The various appendages, so far as seen without dissection, resemble closely those of the female. The basis of the first leg (fig. 46) bears on its inner edge a series of four stout spines.

The basis of the second leg (fig. 48) has its anterior edge cut into a series of fine recurved teeth not observed in the female.

The uropods (fig. 53) are shorter than in the female. The peduncle is shorter than the terminal somite and bears a series of long plumose hairs on its inner edge. The rami are broad and flattened. The endopod has a series of serrate spines on its inner edge increasing in length distally, the two distal spines close to the stout apical one and separated by a little interval from the others; the outer edge and the distal part of the inner edge are serrate. The exopod has several plumose hairs on its inner edge.

Localities.—Gulf of Manaar; several specimens from Kondatchi Paar, one specimen from Periya Paar Kerrai; depth, 8 to 9 fathoms.

This new species resembles a little in general form the *C. australis* of Sars, but differs from it and from all the species of *Cyclaspis* hitherto described not only in the longitudinally-ribbed carapace, but also in the shortness of the first legs, the short abdomen, especially of the female, and in the stoutness and armature of the uropods. In the fact that the first leg-bearing somite is distinct in the female, it agrees with the species described below, but no other species is yet known in which this somite is exposed in the male also.

Cyclaspis picta, n. sp.—Plate III., figs. 54 and 55.

Description of *Female* with rudimentary oostegites. Total length, 3 millims:—

The carapace is a little more than one-third of the total length and is somewhat compressed, the dorsal surface keeled, especially in front. Seen from the side, the dorsal edge is evenly arched, the pseudorostrum is prominent and sharply triangular, the lateral plates meeting in front of the ocular lobe for a distance equal to the transverse diameter of the latter. Antennal notch widely open, antennal tooth sharp, with a spiniform point. Ocular lobe of moderate size, acuminate anteriorly, not sharply constricted off from cephalic lobe, eye well pigmented, corneal lenses not distinct. The sides of the carapace are quite smooth, devoid of ridges or tubercles. The texture of the exoskeleton is (in this specimen) regularly reticulate, with a faintly indicated shallow pitting over the whole of the carapace.

First leg-bearing somite well exposed, but apparently firmly united to the carapace, the suture line being somewhat faintly shown.

Abdomen rather slender, nearly equal in length to the cephalothoracic region, the somites sub-cylindrical, with well-marked articular processes laterally.

First legs comparatively short, extending beyond the antennal tooth by little more than the terminal segment. Second legs with the ischium distinct.

Uropods (fig. 55) having the peduncle nearly twice as long as the last somite and more than twice as long as the rami, which are sub-equal, the endopod especially rather broad and flattened, tipped with a spine, and having two spines on its serrate inner edge. The exopod has a terminal spine and a small spinule close to it on the outer side.

Both the specimens show a peculiarly shaped pigment patch on the carapace. The last thoracic and some of the abdominal somites are also pigmented.

Locality.—Gulf of Manaar, Cheval Paar; depth, 7 fathoms; 2 specimens.

This form belongs, with the two following, to a group of species characterised by the smoothness of the carapace and including *C. longicaudata*, Sars; *C. pusilla*, Sars; *C. levis*, Thomson; and *C. argus*, Zimmer. From all of these it seems to be sufficiently distinguished by the presence of five distinct thoracic somites, by the acute pseudorostrum, and by the much longer peduncle of the uropods.

Cyclaspis herdmani, n. sp.—Plate III., figs. 56 to 59; Plate IV., figs. 60 to 66.

Description of adult *Female*. Total length, 4·4 millims. (fig. 56):—

Carapace nearly $3\frac{1}{2}$ times in total length, moderately compressed. The dorsal edge very slightly arched, keeled anteriorly where there is a shallow depression on either side, and having a more faintly marked double keel posteriorly. The junction of the median with the double keel is marked by a shallow pit. Pseudorostrum truncated, the ocular lobe reaching quite to the tip. Antennal notch narrow, antennal tooth sub-acute. Ocular lobe moderately large, not longer than broad, somewhat projecting dorsally; eye well pigmented, corneal lenses indistinctly defined. Sides of carapace smooth, with a faint pitting over the whole surface.

First leg-bearing somite well exposed in adult (in the young female, as in the male, it is wholly concealed). Second somite slightly crested dorsally.

Abdomen rather slender, a little longer than the cephalothoracic region, the somites sub-cylindrical, with well developed lateral articular processes.

Antennules (fig. 58) having the first segment of peduncle longer than the other two together, the second a little shorter than the third. External flagellum of two segments, internal flagellum not observed in the specimen dissected.

Antenna (fig. 59) produced into a narrow process defined by a distinct suture-line. Two plumose setæ on basal part.

The mouth-parts are normal.

The first legs (fig. 60) extend a little way beyond the pseudorostrum. The basis is rather narrow, and is equal in length to the remaining segments together. At its distal end, on the side which in the natural position of the limb is ventral, it is produced into a stout tooth which reaches to the end of the next segment. The merus and carpus are somewhat expanded, and the carpus, propodus, and dactylus are of equal length.

The second legs (fig. 62) have the ischium distinct, the carpus hardly more than half the length of the merus and little longer than the propodus. The dactylus is shorter than the two preceding segments together and bears three unequal spines at the tip. In the remaining legs (fig. 63) the carpus is sub-equal to the merus.

The uropods (fig. 65) are rather slender, the peduncle about $1\frac{2}{5}$ths the length of the last somite, and equal to the length of the sub-equal rami. Both rami are acutely pointed, without terminal spines, and the endopod bears a series of about six spinules on the middle third of its inner edge.

The last two or three thoracic somites are always more or less pigmented.

Adult *Male*. Total length, 4·3 millims. (fig. 57):—

The carapace resembles in shape that of the female, but is less deep. The ocular lobe is more prominent dorsally and the corneal lenses are large and conspicuous. The antennal notch is shallow and widely open. On the surface of the carapace the dorsal keels and depressions are only faintly indicated. Abdominal somites, as usual, much stouter, and the whole abdomen longer than the cephalothorax.

The first legs (fig. 61) are somewhat longer and more slender than in the female; the basal segment bears on its inner edge a group of spines, and the dactylus is a little shorter than carpus or propodus. The remaining legs do not differ conspicuously from those of the female.

The uropods (fig. 66) have the peduncle fringed on the inner edge with setæ. The exopod is a little longer than the endopod and equal to the peduncle, and has a few plumose hairs on its inner edge. The endopod has about 23 spinules on its inner edge, diminishing in length distally, and leaving the distal third of its length unarmed. Both rami are simply pointed at the tip.

Localities.—Gulf of Manaar, various parts of the Cheval Paar; depth 7 fathoms; several specimens.

This species approaches most closely to *C. levis*, THOMSON, and *C. argus*, ZIMMER. The latter is distinguished in the male sex by a different form of the anterior margin of the carapace, the antennal notch being widely open and shallow, by having the second leg-bearing somite produced dorsally, and by the shorter uropods, of which the peduncle is equal in length to the last somite. *C. levis* is distinguished, according to THOMSON, by having a long, slender and acute process from the distal end of the basal segment of the first legs. I am inclined to suspect some error of observation in regard to this character, in which case *C. levis* would resemble very closely the form here described. The characters of the uropods, however, appear to distinguish the species, those of *C. levis* having the peduncle not longer than the last somite, and their armature being somewhat different.

Cyclaspis hornelli, n. sp.—Plate IV., figs. 67 to 71.

Closely resembling in both sexes the preceding species, but differing from it in the following characters:—The carapace is still smoother, and the dorsal keel is simple and less strongly marked. The first legs (fig. 67) are much longer, reaching far beyond the anterior end of the body; the basis is about three-fourths of the length of the remaining segments together, and the propodus is twice and the dactylus one and a half times as long as the carpus. The second legs (fig. 68) have the terminal segment longer and with more numerous spines. In the last three pairs of legs the distal segments are more elongated, the carpus of the fifth pair (fig. 70) being half as long again as the merus. The uropods (fig. 71) resemble those of *C. herdmani*, but the exopod is a little shorter than the peduncle, and bears three to five spinules about the middle of its inner margin, while at the tip are two unequal spinules and another close to them on the inner edge. The endopod is simply pointed and bears in the female six, and in the male 14 spines on its inner edge. Total length, female 5·3 millims., male 4·2 millims.

Localities.—Gulf of Manaar, Cheval Paar, depth 7 fathoms, several spp., and the Periya Paar Kerrai, depth 8 to 9 fathoms, several.

At the suggestion of Professor HERDMAN, I have pleasure in associating with this

species the name of Mr. James Hornell, to whom, I am told, no small share of credit is due for getting together this interesting series of a group of animals neglected by most collectors.

Iphinoë macrobrachium, n. sp.—Plate IV., figs. 72 to 75.

Description of immature *Female*. Total length, 1 millim. :—

Carapace about one-fourth of the total length, its length in the middle line nearly one and a half times its height, moderately compressed, with a well marked dorsal keel. Dorsal edge slightly arched. Pseudorostrum prominent, upturned, truncated, the lateral plates meeting in front of the ocular lobe for a distance nearly equal to the breadth of the latter. Antennal notch rather deep, angular, antennal tooth acute. Ocular lobe transverse, its width more than twice its length. On the side of the carapace are two very faintly marked longitudinal ridges. The upper is continued backwards for a short distance from the pseudorostrum, the lower is just above the lower margin of the carapace. The free thoracic somites are faintly keeled dorsally.

Antennules and third maxillipeds resembling those of *Iphinoë crassipes*, Hansen. First legs (fig. 73) very long, basis less than half the length of the remaining segments; relative proportions of the latter as in *I. crassipes*, but the propodus rather more slender. Second legs (fig. 74) resembling those of *I. crassipes*, the two distal segments indistinctly separated.

Uropods (fig. 75) with the peduncle stout and a little longer than the last somite, with five or six strong spines on its inner edge. Rami unequal, the endopod a little longer than the peduncle, its proximal segment with four or five spines on its inner edge, and nearly half as long again as the distal segment, which has three terminal spines and two or three on its inner edge. Exopod about two-thirds of the length of the endopod, unarmed except for the terminal group of six or seven spines and stout setæ.

Localities.—Gulf of Manaar, Cheval Paar, 7 fathoms, 1 specimen, and Kondatchi Paar, 4 to 5 fathoms, 1 specimen.

This species presents a close resemblance to the *Iphinoë crassipes* of Hansen from the Gulf of Guinea. Although Hansen's specimen, like those here described, was immature, there appear to be sufficient grounds for regarding the species as distinct. The outline of the carapace is somewhat different, the basal segment of the first legs is much shorter, and the rami of the uropods are conspicuously unequal, while in *I. crassipes* they are nearly of the same length.

Family: DIASTYLIDÆ.

Paradiastylis, n. gen.

Third maxillipeds without exopod. Third and fourth pairs of legs with no rudi-

ments of exopods. Telson very short, the post-anal part reduced to a spiniform process tipped with two small spinules and without lateral spines.

Paradiastylis brachyura, n. sp.—Plate V., figs. 76 to 90.

Description of sub-adult *Female*. Total length 3·2 millims. :—

Carapace inflated, a little less than one-third of the total length, its breadth about three-fourths, and its depth two-thirds of its length. Pseudorostrum acute, horizontal, the lateral plates meeting in front of the ocular lobe for a distance equal to the width of the latter. The tip of the pseudorostrum is armed with a pair of divergent spines. Antennal notch shallow. Antero-lateral angle not produced, rounded, serrate. On each side of the carapace are four curved ridges running obliquely from above downwards and forwards. The most anterior and strongest of these is serrate, and the area in front of and above it is depressed on each side, leaving a median keel. The fourth or hindmost ridge on either side is much less prominent than the others. On the dorsal surface a pair of short longitudinal serrate crests, some distance apart, connect the upper ends of the first and second ridges, and form a strong tooth at the upper end of the first. The median keel bears two procurved teeth, and a pair are set side by side on the ocular lobe. On the lower part of the side of the carapace anteriorly a curved row of spines starting from the pseudorostrum runs backwards and downwards towards the lower margin, crossing the lower ends of the oblique ridges. The posterior edge of the carapace is raised to form a marginal ridge which is strongest on the dorsal side. The ocular lobe is twice as broad as long. There is no eye-pigment nor distinct corneal lenses.

The posterior angles of the last thoracic somite are not produced.

The abdomen is slender, about equal in length to the cephalothoracic region. The somites have slight serrate dorso-lateral crests. The fifth somite is not greatly elongated.

Telson (figs. 89 and 90) a little shorter than the last somite, somewhat narrowed at its base, its greatest breadth at about one-third of its length from the base, where it bears a pair of lateral tubercles, then narrowing suddenly a little before the middle of its length, the sides converging to an acute point. Viewed from the side (fig. 89), the tip is seen to project beyond the obliquely placed anal valves by about one-third of its length. A pair of very minute apical spinules are present, flanked by a pair of small setæ, with another pair of setæ a little way further down the side.

Antennules (figs. 78 and 78A) hardly reaching beyond the tip of the pseudorostrum, the proximal segment more than twice, the third segment one and a half times the length of the second. Outer flagellum shorter than the last segment of the peduncle, consisting of three segments, the terminal one very minute. Inner flagellum two-thirds the length of the outer, composed of two segments, the proximal very short.

Antennæ (fig. 80) consisting of three segments.

Mouth-parts of normal type. Mandibles with about nine spines. Lobes of lower

lip with incurved tips. Palp of maxillulæ (fig. 81) not longer than the distance between its base and the tip of the distal lobe, with two apical setæ. Branchial apparatus not examined. Second maxillipeds (fig. 82) rather short, basis hardly more than one-third of the total length.

Third maxillipeds (figs. 83) without exopods. The basis is curved, much expanded distally and about equal in length to the remaining segments together. At its distal end it bears a series of very long setæ.

First legs (fig. 84) reaching beyond the tip of the pseudorostrum by about half the length of the carapace. The basis rather short, less than two-fifths the length of the remaining segments; the distal segments stout, propodus a little longer than the carpus and more than twice as long as the dactylus.

Second legs (fig. 85) about as long as the third pair, basis enlarged, ischium reduced to a narrow ring, distal segments not greatly elongated, propodus three-fourths of the length of the dactylus, which is armed with two or three apical spines and several setæ. Remaining legs (figs. 86 and 87) rather stout, successively diminishing in length, merus much longer than carpus.

Uropods (fig. 88) slender and elongate, peduncle twice as long as the sixth abdominal somite, with six spines on distal part of its inner edge, two tubercles on its lower surface and one above. Rami slightly unequal, exopod a little more than half the length of the peduncle and a little shorter than the endopod, unarmed except for a few minute setæ and for a slender apical spine equal in length to the ramus carrying it. Exopod of three segments, of which the first and longest bears two spines and each of the others one on the inner edge; distal segment ending in a slender apical spine.

No adult male is in the collection, but one or two immature male specimens, resembling the female in general form and in the sculpture of the carapace, have the antennular peduncle (fig. 79), and especially its distal segments, much enlarged, suggesting that in the adult a modification of this appendage may take place similar to that occurring in *Leptostylis;* the outer flagellum also possesses an additional segment not observed in the female. Two pairs of pleopods are present as rudiments and both are bilobed.

Locality.—Gulf of Manaar, Cheval Paar, 7 fathoms; several specimens.

The most remarkable feature of the present form, and one which distinguishes it from all *Cumacea* hitherto described, is the absence of an exopod from the third maxilliped. The facility with which this appendage becomes detached in dissection from the limb which carries it, might suggest possible error of observation on this point were it not that I have observed the same character in an undescribed species from New Zealand, closely allied to that above described. This character is so unusual that it seems advisable to recognise it by establishing a new genus for the reception of the species.

The *Leptostylis brevicaudata* described by Zimmer ('Zool. Jahrb. Syst.,' XVIII.,

p. 685), from Japan, presents a great resemblance to this species in general form, in the shape and proportions of the telson, and in the sculpturing of the carapace. Its third maxilliped is not described, but it possesses rudimentary exopods on the third and fourth legs, a character which led to its being referred to the genus *Leptostylis*, although differing in several points from the typical members of that genus. Should it prove to be the case that *L. brevicaudata* is without an exopod on the third maxilliped, it will, I think, be necessary to include it with the present species in the genus *Paradiastylis* in spite of the difference in structure of the third and fourth legs. In the *Diastylopsis dubia* of BONNIER ('Ann. Univ. Lyon,' "Campagne du 'Caudan,'" Édriophthalmes, p. 559), the presence or absence of rudimentary exopods on these limbs seems to be a matter of individual variation, suggesting that no great importance can attach to this feature as a generic distinction within the family Diastylidæ.

FAMILY: NANNASTACIDÆ.

Nannastacus stebbingi, n. sp.—Plate V., figs. 91 to 93.

Description of adult *Male*. Total length, 1·38 millims.:—

Carapace a little over one-third of total length, rather broader than deep, dorsal surface a little depressed in middle line between the swollen branchial regions. On either side, a little way behind the eye, is a rounded knob-like prominence (present also, although less conspicuous, in *N. unguiculatus*). Pseudorostrum, seen from the side, upturned and rounded, with two faintly marked ridges parallel to its distal margin; immediately below the pseudorostrum, and above the insertion of the antennule, the concave antero-lateral margin bears a group of three curved spines, of which the upper and largest is very conspicuous. Antero-lateral angle not produced, rounded, not serrate, but with a single small spine springing from the outer surface. Seen from above, the pseudorostral plates do not meet in front of the eyes and the respiratory channel is widely open. The eyes are large, each with three prominent corneal lenses. The width of the interocular margin is about equal to the diameter of the eye.

All the free thoracic somites have sub-marginal lateral crests of laminar spines, the last three also with paired serrated crests on the dorsal surface.

Abdomen shorter than the cephalothoracic region, fifth somite not much longer than the preceding. As in *N. unguiculatus*, all the somites bear serrated lateral crests overhanging the lateral grooves, and each, except the last, has a pair of stouter dorsal crests ending behind in a strong curved tooth. On the last somite, apparently, the lateral crests alone are present running on to the dorsal surface, and the posterior border of the somite is produced into a sharp median spine.

In the last pair of legs the carpus is longer than the propodus.

Uropods (fig. 93), excluding the apical spines, longer than the last two somites;

peduncle very short, with a serrate crest on the dorsal surface; endopod about three times as long as the peduncle, serrate on the inner edge, and having an apical spine nearly two-thirds of its own length, with two short spines at its base internally; exopod nearly half as long as the endopod, apical spine one and a half times the length of the ramus.

Locality.—Gulf of Manaar, $2\frac{3}{4}$ miles south-south-west of Chilavaturai, depth 2 fathoms; 1 specimen.

This species resembles generally the male of *N. unguiculatus*, but differs in the smoother carapace, in the antero-lateral angle, not serrate, but having a single apical spine, in the group of spines below the pseudorostrum, and in the greater relative length of the exopod of the uropods. The *N. ossiani* described by Mr. STEBBING (WILLEY'S 'Zool. Results,' Part V., Crustacea, p. 612) resembles the present species in the concentric ridges of the pseudorostrum, which, however, appear to be much more strongly marked than in our specimen. It differs in the stouter abdomen, in the more pronounced dorsal depression of the carapace, in the last two thoracic somites, which have the "dorsal centre strongly raised," without the double dorsal crests, and in the absence of the group of spines below the pseudorostrum. Owing to an accident to the present specimen I am unfortunately unable to state exactly the relative proportions of the segments of the last pair of legs. As far as could be seen in the undissected specimen, however, the difference in length between the carpus and propodus was less than in *N. ossiani*. Mr. STEBBING compares his species with the female of SARS' *N. suhmii*, which he suggests may be specifically distinct from the male with which SARS has associated it. The arguments given in favour of this suggestion are not very conclusive, and in particular Mr. STEBBING'S remark that in *N. unguiculatus* "the sexual dimorphism so common in the present order is less striking than usual" does not seem at all applicable to that species. A re-examination of the type specimens of *N. suhmii* in the "Challenger" collection does not support Mr. STEBBING'S suggestion. The specimens, in consequence of the Canada balsam becoming opaque, have had to be removed from the slide on which they were mounted and are therefore more accessible for examination than formerly. I find that the male specimens almost certainly belong to two species, but that the larger and better preserved among them, which alone correspond with SARS' figure (except that the antero-lateral angle of the carapace is less narrowed and produced than is there shown), agree with the female specimen and differ from all the species of *Nannastacus* hitherto described in the extreme reduction of the exopod of the uropods. In the males this ramus, including its terminal spine, does not exceed one-fourth of the total length of the endopod.

EXPLANATION OF PLATES.

PLATE I.

Fig. 1. *Eocuma taprobanica*, n. sp., sub-adult female, from side.
,, 2. ,, ,, ,, ,, above.
,, 3. ,, ,, adult male, from side.
,, 4. ,, ,, ,, ,, above.
,, 5. ,, ,, young specimen, outline of carapace, from above.
,, 6. ,, ,, female, anterior part of body, from below.
,, 7. ,, ,, antennules and antenna of female.
,, 8. ,, ,, antennule of male.
,, 9. ,, ,, basal part of antenna of male.
,, 10. ,, ,, mandible of female.
,, 11. ,, ,, lower lip.
,, 12. ,, ,, maxillula.
,, 13. ,, ,, first maxilliped, with branchial apparatus of female.
,, 14. ,, ,, ,, ,, ,, male.
,, 15. ,, ,, second maxilliped of female.
,, 16. ,, ,, third maxilliped, from below.
,, 16A. ,, ,, part of same, from above.
,, 17. ,, ,, second leg of female.
,, 18. ,, ,, third ,,
,, 19. ,, ,, fourth ,,
,, 20. ,, ,, fifth ,,

PLATE II.

Fig. 21. *Eocuma taprobanica*, first leg of female.
,, 22. ,, ,, male.
,, 23. ,, second leg of male.
,, 24. ,, third ,,
,, 25. ,, fourth ,,
,, 26. ,, fifth ,,
,, 27. ,, last somite and uropod of female, from above.
,, 27A. ,, uropod from side.
,, 27B. ,, tip of exopod of uropod, further enlarged.
,, 28. ,, last somite and uropod of male, from above.
,, 29. *Eocuma affinis*, n. sp., adult male, from side.
,, 30. ,, ,, carapace of same, from above.
,, 31. ,, ,, portion of surface of carapace, further enlarged.
,, 32. ,, ,, first leg.
,, 32A. ,, ,, ,, distal end of basal segment, from above.
,, 33. ,, ,, second leg.
,, 34. ,, ,, last somite and uropod.
,, 35. *Eocuma sarsii* (KOSSMANN), female, from side.
,, 36. ,, ,, ,, above.
,, 37. ,, ,, portion of surface of carapace, further enlarged.
,, 38. ,, ,, last somite and uropod.

PLATE III.

Fig. 39. *Cyclaspis costata*, n. sp., adult female, from side.
,, 40. ,, ,, ,, ,, above.
,, 41. ,, ,, adult male, from side.
,, 42. ,, ,, antennule of female.
,, 43. ,, ,, antenna ,,
,, 44. ,, ,, third maxilliped.
,, 45. ,, ,, first leg of female.
,, 46. ,, ,, ,, male.
,, 47. ,, ,, second leg of female.
,, 48. ,, ,, ,, male.
,, 49. ,, ,, third leg of female.
,, 50. ,, ,, fourth leg ,,
,, 51. ,, ,, fifth leg ,,
,, 52. ,, ,, last somite and uropod of female.
,, 53. ,, ,, ,, ,, male.
,, 54. *Cyclaspis picta*, n. sp., immature female.
,, 55. ,, ,, last somite and uropod.
,, 56. *Cyclaspis herdmani*, n. sp., adult female.
,, 57. ,, ,, ,, male.
,, 58. ,, ,, antennule of female.
,, 59. ,, ,, antenna ,,

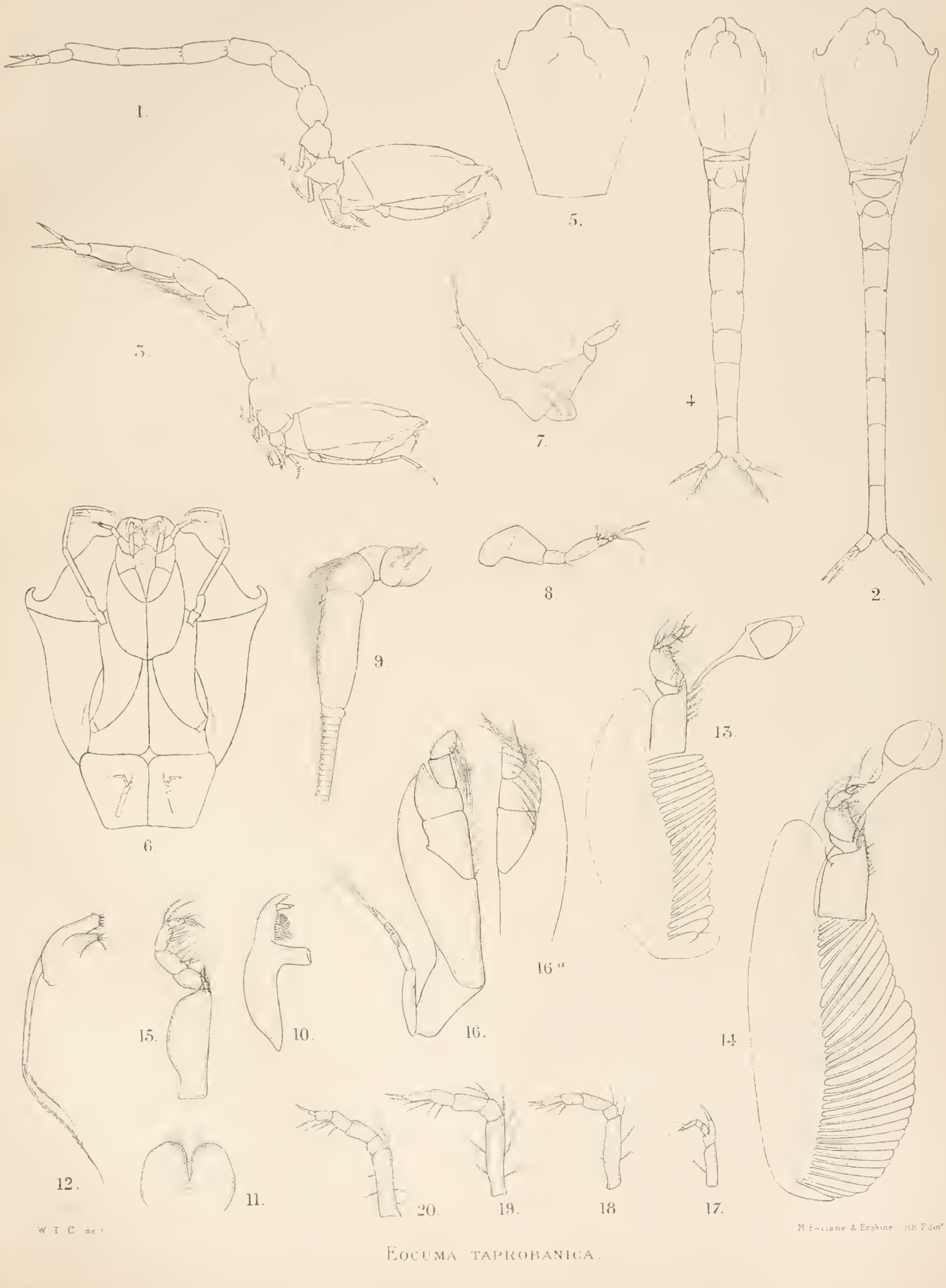
PLATE IV.

Fig. 60. *Cyclaspis herdmani*, first leg of female.
,, 61. ,, ,, male.
,, 62. ,, second leg of female.
,, 63. ,, fourth ,,
,, 64. ,, fifth ,,
,, 65. ,, last somite and uropod of female.
,, 66. ,, ,, ,, male.
,, 67. *Cyclaspis hornelli*, n. sp., first leg of male.
,, 68. ,, ,, second leg of male.
,, 69. ,, ,, third ,,
,, 70. ,, ,, fifth ,, terminal segments.
,, 71. ,, ,, last somite and uropod of female.
,, 72. *Iphinoë macrobrachium*, n. sp., young female, from side.
,, 73. ,, ,, first leg.
,, 74. ,, ,, second leg.
,, 75. ,, ,, last somite and uropod.

PLATE V.

Fig. 76. *Paradiastylis brachyura*, n. sp., sub-adult female, from side.
,, 77. ,, ,, ,, above.
,, 78. ,, ,, antennule of adult female.

Fig. 78A.	*Paradiastylis brachyura*, n. sp.,	terminal part of same, further enlarged.
,, 79.	,, ,,	antennule of young male, terminal part.
,, 80.	,, ,,	antenna } of adult female.
,, 81.	,, ,,	maxillula } of adult female.
,, 82.	,, ,,	second maxilliped } of adult female.
,, 83.	,, ,,	third maxilliped } of adult female.
,, 84.	,, ,,	first leg } of adult female.
,, 85.	,, ,,	second leg } of adult female.
,, 86.	,, ,,	fourth ,, } of adult female.
,, 87.	,, ,,	fifth ,, } of adult female.
,, 88.	,, ,,	last somite, telson and uropod of young male.
,, 89.	,, ,,	,, and telson from side.
,, 90.	,, ,,	telson of a female specimen.
,, 91.	*Nannastacus stebbingi*, n. sp.,	male, from side.
,, 92.	,, ,,	,, above.
,, 93.	,, ,,	last somite and uropod.



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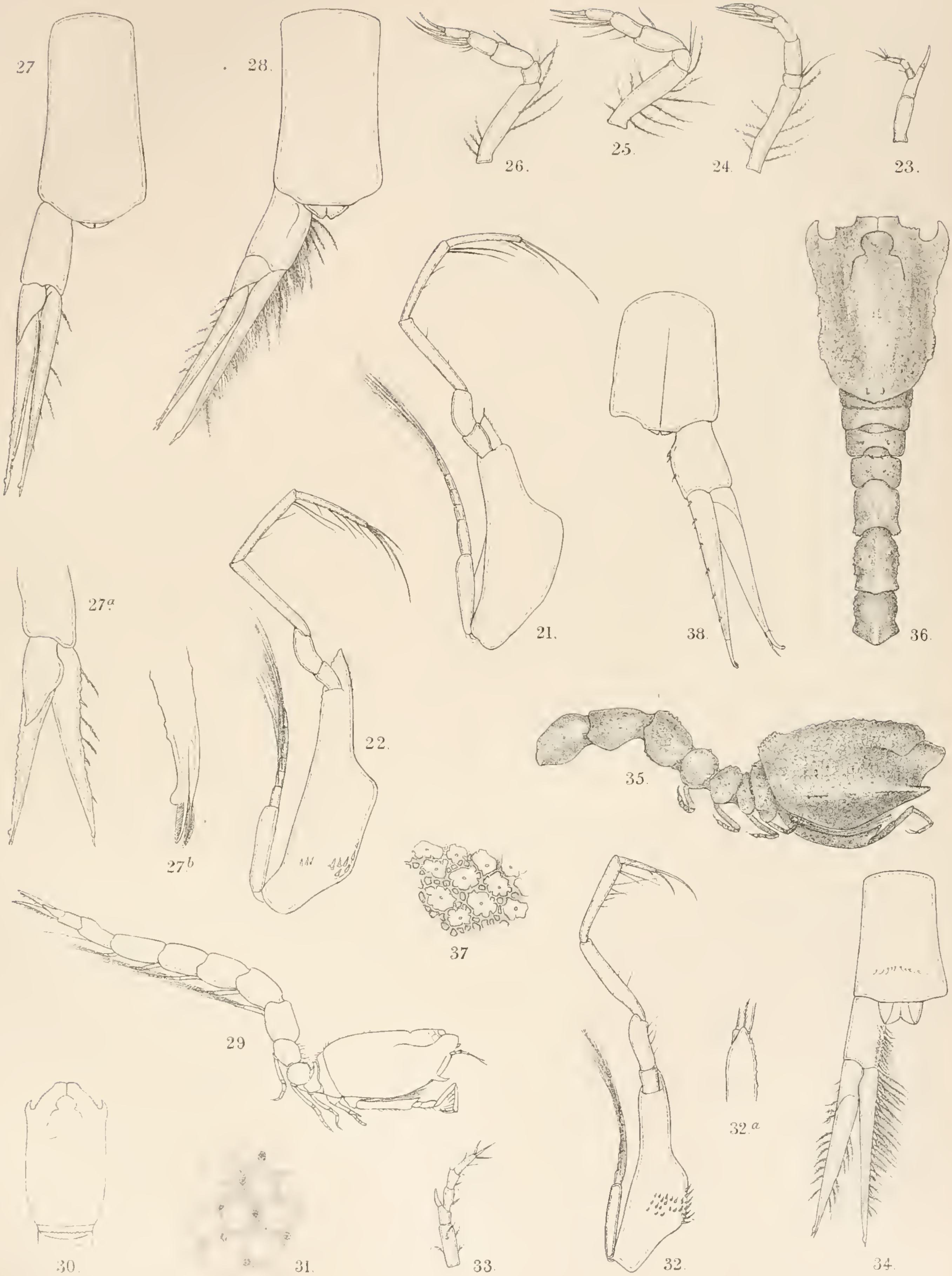
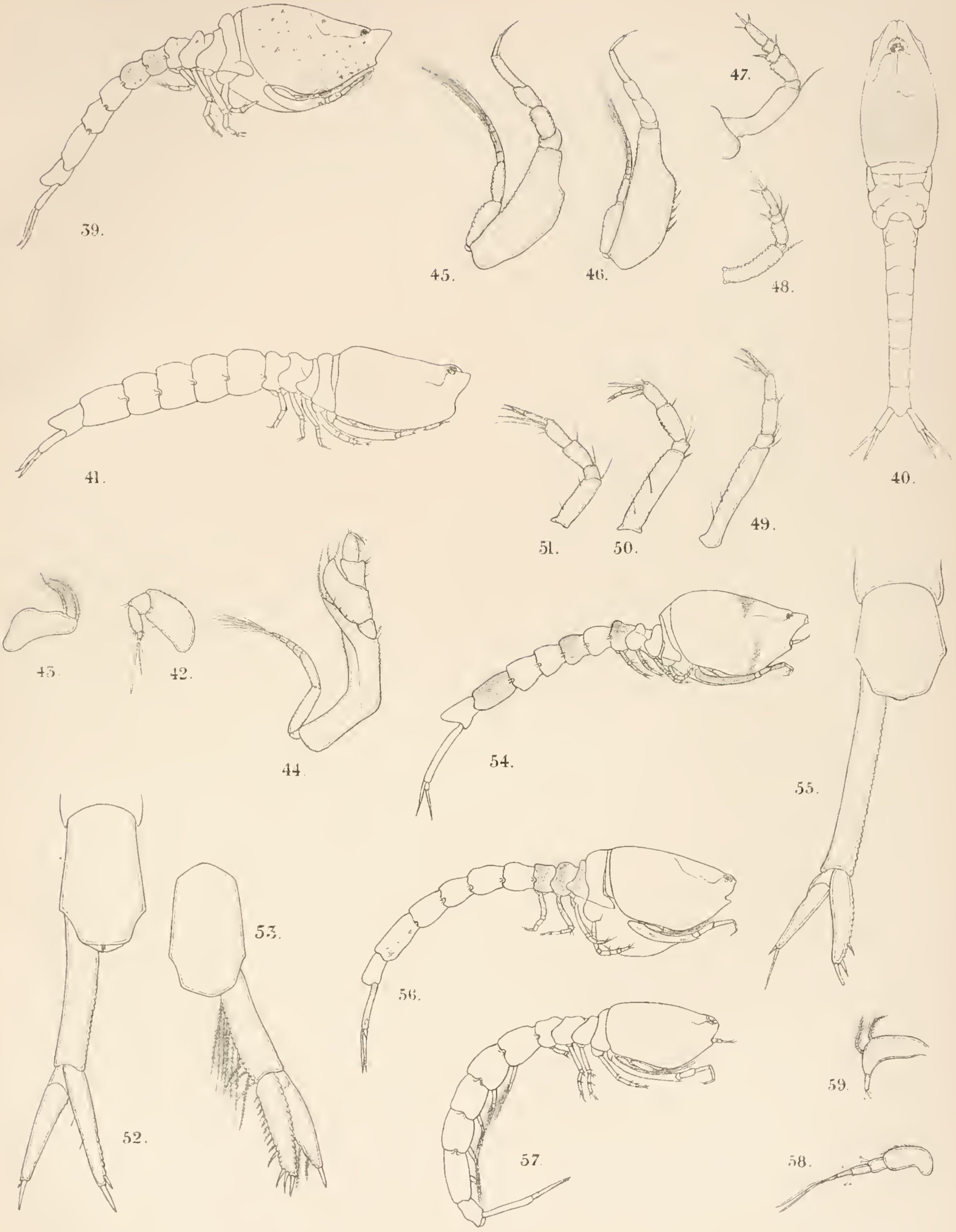
EOCUMA TAPROBANICA.



FIGS. 21-28, EOCUMA TAPROBANICA. FIGS. 29-34, EOCUMA AFFINIS. FIGS. 35-38, EOCUMA SARSII



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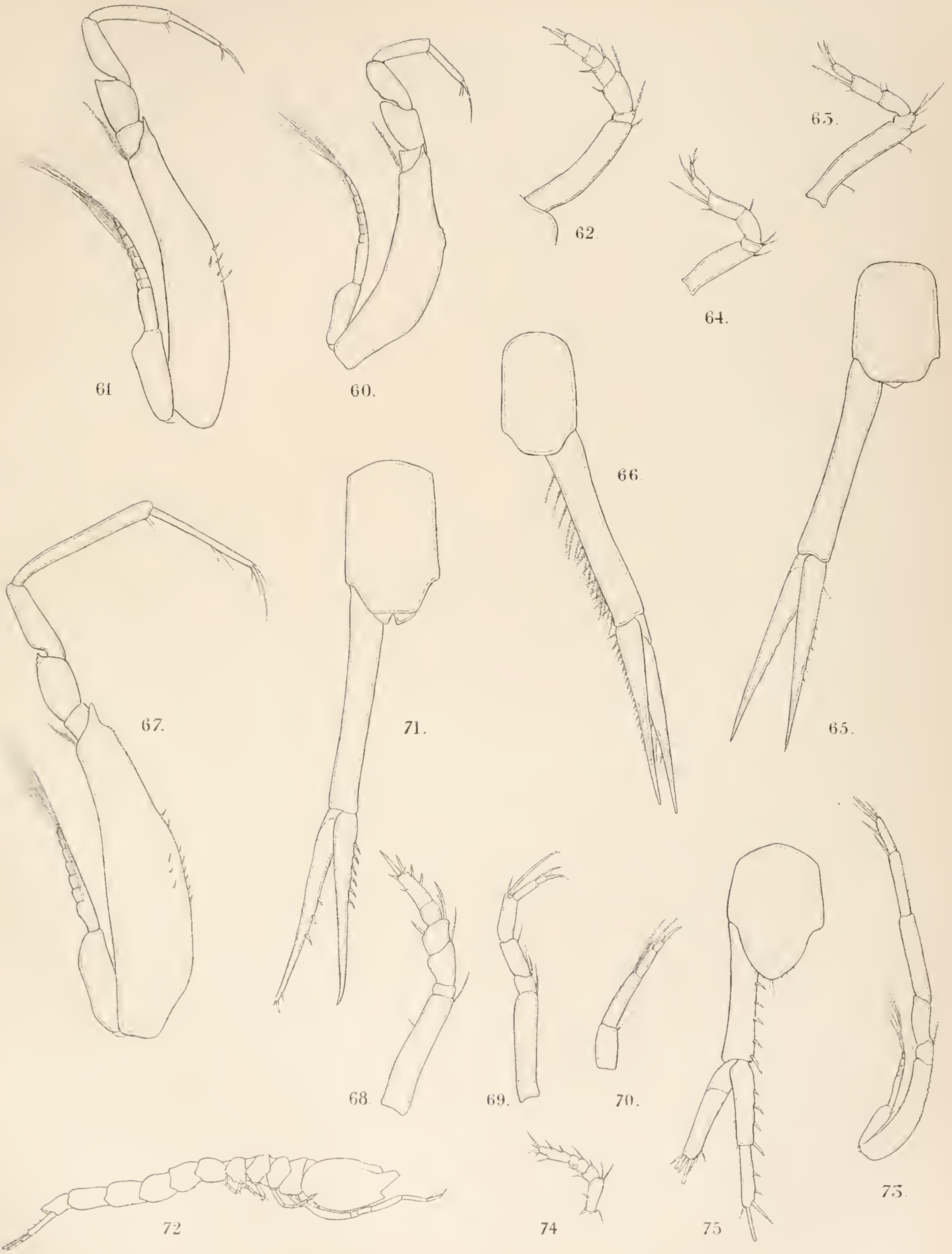
FIGS. 39-53, CYCLASPIS COSTATA. FIGS. 54, 55, CYCLASPIS PICTA. FIGS. 56-59, CYCLASPIS HERDMANI



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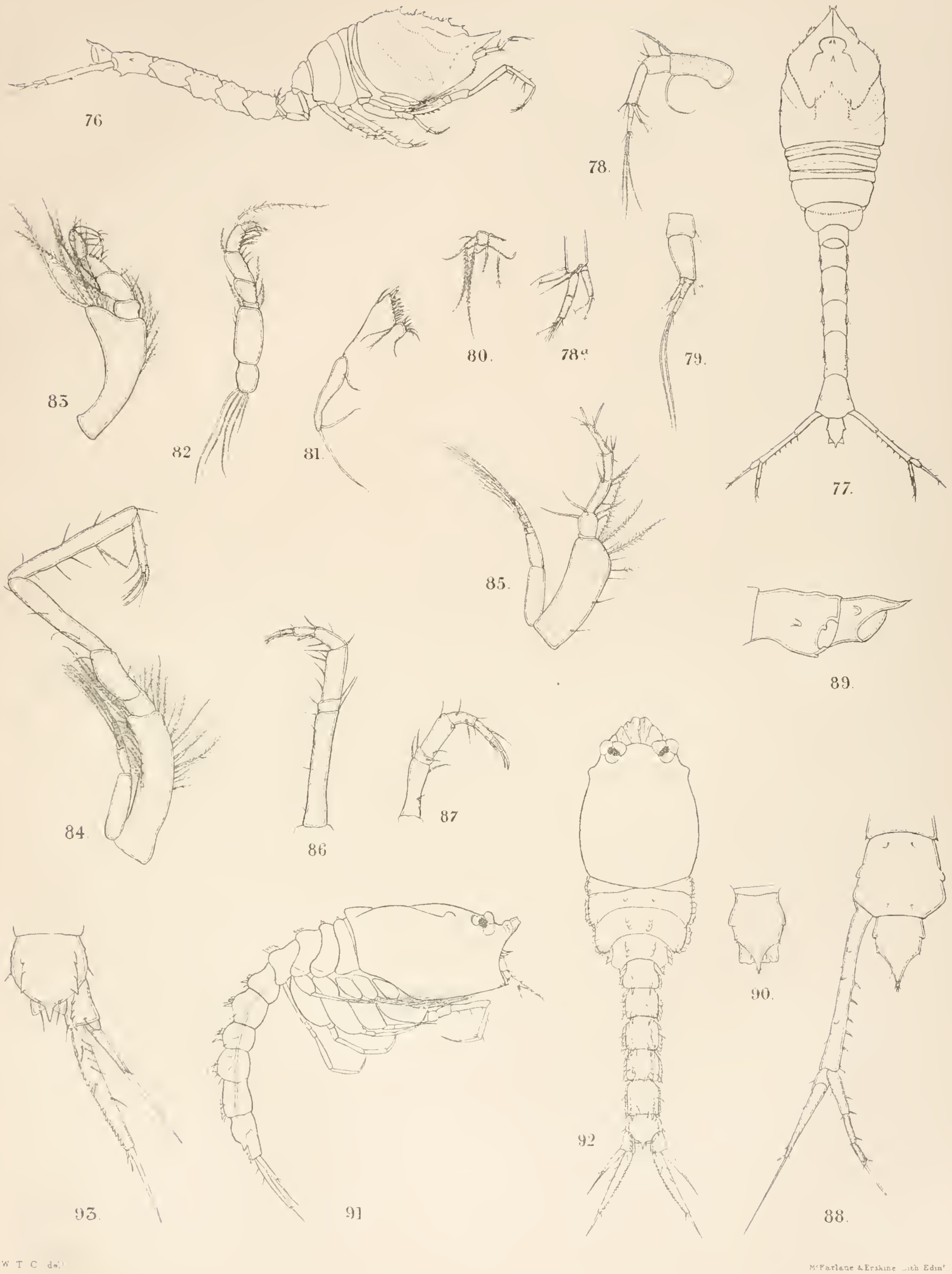
Figs 60-66, Cyclaspis herdmani Figs 67-71, Cyclaspis hornelli Figs 72-75, Iphinoe macrobrachium



Figs. 76-90. Paradiastylis brachyura. Figs. 91-93. Nannastacus stebbingi.

REPORT

ON THE

PANTOPODA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

GEO. H. CARPENTER, B.Sc., M.R.I.A.,
OF THE SCIENCE AND ART MUSEUM, DUBLIN.

[WITH ONE PLATE.]

THE Pycnogons collected by Professor HERDMAN and his colleague comprise two species, both obtained in comparatively shallow water in the Gulf of Manaar and along other parts of the Ceylonese coast. One belongs to *Nymphon* and the other to *Phoxichilus*, both widely distributed genera, ranging from the Arctic Ocean to the southern seas. *Nymphon* is, however, a genus much richer in species, and shows a wider distribution than *Phoxichilus*. Both the forms seem to be referable to new species, and as numerous individuals have been collected in an excellent state of preservation, it is easy to describe and figure their distinctive characters. The *Nymphon* is abundantly distinct from any known species. *Phoxichilus*, on the other hand, is a genus whose named forms are of doubtful "specific" value. But all the more on that account is a careful study of specimens from new localities desirable as a guide to the extent and nature of variation.

I am much indebted to Professor HERDMAN for entrusting me with this interesting, if small, collection for examination and report.

Family : PHOXICHILIDÆ.

Phoxichilus, Latr.

Phoxichilus mollis, n. sp.—Plate, figs. 1–7.

Length 5 millims. Body proportioned as in *P. lævis*, Grube,* but almost entirely unarmed, only a few minute spines on the lateral processes and on the head-segment (figs. 1, 2). Femur of each leg evenly swollen distally without angular projections, armed only with a series of minute spines along the edges and four terminal spines (figs. 1, 3). Male with 24 cement glands on each femur (figs. 3, 4, *c.g.*). False leg of male with 6th segment greatly thickened and enlarged laterally (figs. 5, 6). Propodus with 5 stout basal teeth (the 3rd the longest) and 6 small distal teeth (fig. 7).

Habitat :—Coasts of Ceylon. Two males and several females picked off experimental oyster cage hung over side of ship on the North-East Cheval Paar, 15th February, 1903. Cheval Paar, 2 males, one with eggs and one young female. Deep water off Galle ; young female.

The above characters will serve to distinguish this species from any form of *Phoxichilus* hitherto described, the feeble armature of the trunk and femora being the most striking character. The armature of the tibial segments, though feebler than in the European forms, approaches the usual type of the genus, while the tarsus, propodus, and claws differ but slightly from those of other species of *Phoxichilus*. It seems, therefore, that the loss of spines begins on the trunk and extends slowly towards the extremities.

The two forms of *Phoxichilus* most nearly related to the present species are *P. meridionalis*, Böhm,† from Singapore, and the problematical *P. inermis*, Hesse.‡ The former of these, however, has very prominent spines on the femur, and seems to approach *P. lævis* rather closely, while the latter is said to be 10 millims. long, with almost entirely unarmed legs and a 3-segmented abdomen (the last statement needs confirmation).

I have elsewhere§ drawn attention to the slight comparative characters by which the various described forms of *Phoxichilus* are distinguished from one another, and I think it likely that when specimens of this genus have been obtained from many other parts of the world, it will be impossible to maintain "specific" distinctions. Already we have a series beginning with the well-armed *P. spinosus*, Mont., passing through *P. lævis*, Grube, *P. vulgaris*, Dohrn, *P. meridionalis*, Böhm, to *P. mollis* and *P. inermis*, Hesse, in which the spiny armature has become, to a great extent, lost. And it is of special interest in this connection to note that in one of the Ceylon

* 'Abhandl. d. Schles. Gesellsch. f. vaterl. Cultur,' 1869–72, p. 124–126, Taf. 1, fig. 1.

† 'Monatsber. d. Königl. Akad. Wissensch. Berlin,' 1879, p. 189–191, Plate 2, fig. 4.

‡ 'Ann. Sci. Nat.' (Zool.), (5), vii., 1867, pp. 199–201.

§ 'Sci. Proc. R. Dublin Soc.,' vol. viii., 1893, pp. 200–202.

males of *P. mollis*, the femur both in its form and armature (fig. 3A) shows some approach to what we find in the European species of *Phoxichilus*. The young individuals, too, are markedly spinose as compared with the adults.

The colour of these Ceylon specimens is a pale yellowish-green, the food-canal showing through the semi-transparent body in bluish-green streaks. The male carries the eggs in a large flat cake-like mass of somewhat irregular form (fig. 3).

Family: NYMPHONIDÆ.

Nymphon, Fabr.

Nymphon longicaudatum, n. sp.—Plate, figs. 8–14.

Length, 6 millims. to 8 millims. Head segment nearly as long as the three thoracic segments taken together, neck slender and elongate. Proboscis swollen centrally and constricted behind mouth (fig. 8). Eye eminence with low conical apex (fig. 9). Chelifori elongate; scape nearly as long as proboscis; hand rather longer than scape, with slender, tapering, evenly curved fingers (figs. 8, 10). Palp half as long as body; relative length of its segments as 2 : 8 : 9 : 10 : 6. False leg as long as body; relative length of its segments as 2 : 4 : 4 : 20 : 24 : 10 : 6 : 4 : 4 : 3; denticulate spines with a short sharp basal point, and six to eight sinuous serrations on each side (figs. 11, 12, 13). Legs slender and elongate, spines present only at the tip of the second tibial segment; propodus four times as long as tarsus; principal claw slender, slightly longer than tarsus; auxiliary claws four-fifths as long as principal claw (fig. 14). Abdomen very elongate, slender and club-shaped (fig. 8); as long as the first two thoracic segments together. Colour of body and legs yellow, with a variable amount of dark pigment which is specially well developed along two lateral longitudinal lines on the thoracic segments.

Habitat:—Gulf of Manaar, coral reefs and pearl banks, February and March, 1902. South of Manaar Island (Station LIV., 8 to 9 fathoms), March 8th, 1902. West of Periya Paar (Station LXI., 12 fathoms), March 12th, 1902.

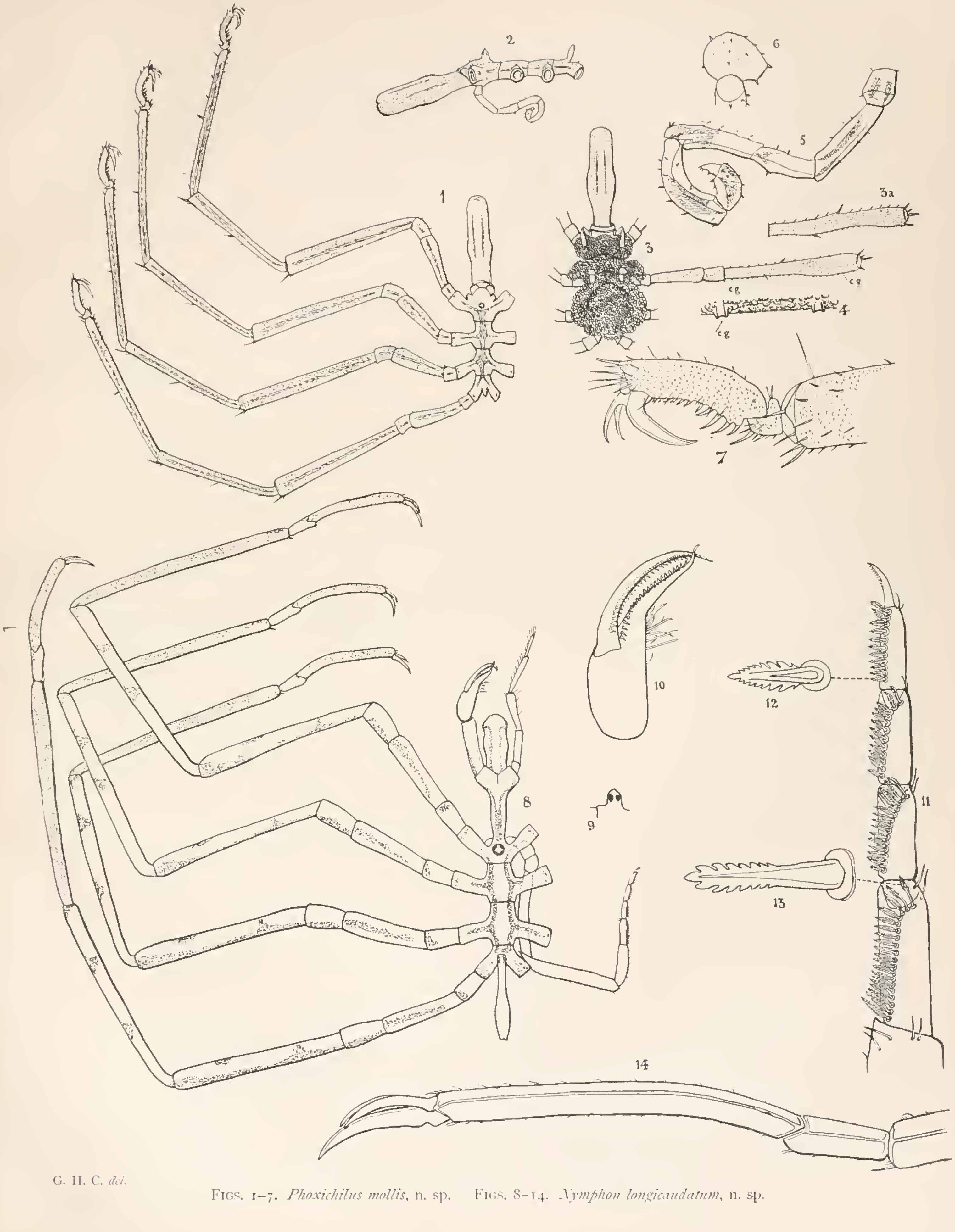
This *Nymphon* is markedly distinguished from any species of the genus known to me by the elongate abdomen, the proportion of the tarsus to the propodus, and the distinct linear pattern on the trunk segments due to the dark pigment. The almost complete absence of spines on the body and legs—which are clothed only with a few scattered, minute hairs—is another striking character.

As usual in this genus, there is no marked difference between the sexes. In the female the proboscis and neck are relatively shorter than in the male.

It is of interest to note that both these species are remarkably poor in spiny or hairy armature or clothing as compared with other members of their genera. Possibly those naturalists who have had the good fortune to observe the animals amid their natural surroundings may be able to suggest some explanation of this modification.

EXPLANATION OF PLATE.

Fig. 1.	*Phoxichilus mollis*, n. sp.	Female.	Dorsal view. × 9.
,, 2.	,, ,,	Male.	Side view. × 9.
,, 3.	,, ,,	,,	Ventral view. × 9. *c.g.*, cement glands.
,, 3A.	,, ,,	,,	(Another specimen.) Femur showing variation for comparison with fig. 3. × 9.
,, 4.	,, ,,	,,	Hind edge of femur, showing two cement gland openings (*c.g.*). × 460.
,, 5.	,, ,,	,,	False leg. × 32.
,, 6.	,, ,,	,,	End of 5th and 6th segment. Ventral view. × 32.
,, 7.	,, ,,	Female.	Tarsus and propodus. × 36.
,, 8.	*Nymphon longicaudatum*, n. sp.	Male.	Dorsal view. × 9.
,, 9.	,, ,,	,,	Eye eminence. × 9.
,, 10.	,, ,,	,,	Cheliforus. × 27.
,, 11.	,, ,,	,,	Terminal segments of false leg. × 50.
,, 12.	,, ,,	,,	} Serrated spines of false leg. × 230.
,, 13.	,, ,,	,,	}
,, 14.	,, ,,	,,	Tarsus and propodus. × 32.



G. H. C. *del.*

FIGS. 1–7. *Phoxichilus mollis*, n. sp. FIGS. 8–14. *Nymphon longicaudatum*, n. sp.

REPORT

ON THE

CEPHALOPODA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

WILLIAM E. HOYLE, M.A., D.Sc.,
DIRECTOR OF THE MANCHESTER MUSEUM.

[WITH THREE PLATES.]

THE collection of CEPHALOPODA, though small, contains several forms of interest. The greatest novelty is a small Octopus, with branched processes scattered over the body, which I have named *Polypus arborescens*. In the integument of these processes are certain peculiar organs, which I have described as well as the state of preservation of the specimens would allow.

A very striking peculiarity of the collection is the preponderance of Octopods; the Decapods are represented only by very few forms, and there is an entire absence of any of the usual pelagic types, owing, no doubt, to the collection having been made for the most part in shallow water on a continental shore.

The number of small Octopods is very large; judging from it these little creatures must swarm on the reefs in those regions. Though very interesting, these immature forms are very baffling and in some respects unsatisfactory as material for a report. In the first place, it is impossible to name them. Their distinctive marks admit of their being grouped pretty readily into sets which presumably correspond to species, but to which of the numerous named adult forms they belong it is quite impossible to say. So far as I am aware, no one has yet studied or described the changes which take place in an Octopus from the time of its emergence from the egg till it attains maturity, and as we are ignorant of this in the commonest forms, it is hopeless to expect the information in the case of the rarer exotic species. I have, therefore,

contented myself with describing the more conspicuous varieties of these young Octopods, but without affixing any specific names.

The information given by these young specimens is, however, satisfactory, inasmuch as it shows that even at so early a period different forms can be separated from each other by characters as definite as those which are used in the discrimination of the adult species, not that this is saying much in the case of Octopods, for we are still very much in the dark as to the best specific characters and the range of variation in this bewildering genus.

List of Stations

at which Cephalopoda were obtained, with the species collected at each. The numbers in square brackets correspond to my register of specimens examined :—

STATION I.—First haul of trawl, 31.1.02; 5 miles west and south-west of Negombo; 12 to 20 fathoms; bottom coarse yellow sand with a few dead shells; temperature of sea, 77·5° F.

Sepia rouxi [246].

STATIONS II. and III.—West Ceylon, 1.2.02; various localities between Negombo and Chilaw; 4 to 5 miles off land; depth 8 to 14 fathoms.

Polypus arborescens, n. sp. [213–215].
,, C [203, 204].
,, E [202].
,, G [208].
Polypus J [205, 206].
,, *macropus* (?) [230].
,, *granulatus*, juv. [195].

STATION LVI.—Half-a-mile east of Dutch Modragam, 2nd haul, 10.3.02; depth 8 to 9 fathoms; bottom coarse quartz sand, with red weed.

Polypus aculeatus [200].
Polypus B [244].

STATION L. or LI.—Pearl banks, Cheval Paar, 4.3.02; depth 7 to 8 fathoms; bottom sand and dead shells.

Polypus C [196].

STATION LXV.—South end of Cheval Paar.

Polypus herdmani, n. sp. [231].
Polypus granulatus [211].

STATION XVI.—On Periya Paar; depth 9 fathoms; bottom varied, sand to Nullipores and Coral.

Polypus arborescens, n. sp. [217].
Polypus herdmani, n. sp. [216].

STATIONS IX. to XIV., XLVIII. and XLIX.—Pearl banks, Gulf of Manaar, Cheval district.

Polypus herdmani, n. sp.	[224–226, 228, 229].	*Polypus macropus*, juv. (?)	[275].
,, *arborescens*, n. sp.	[212, 239–243].	,, A	[233–237, 636 (?)].
,, *aculeatus*	[218–221, 266, 276, 630–632].	,, B (?)	[635].
,, ,, (?)	[197].	,, C	[247–261, 633].
,, *granulatus*	[222, 223, 238].	,, D	[227, 267, 638].
,, *boscii*	[271].	,, G	[194].
,, ,, var. *pallida*	[272, 274].	,, H	[209, 210].
		Inioteuthis maculosa	[198].
		Euprymna morsei	[245].
		Sepia singalensis	[270].

STATION XVIII.—Palk Bay, 14.3.02; south-east of Catchetivo Island; 7 fathoms.

Polypus C [199]. | *Polypus granulatus* [268, 269].

STATION XIX.—Palk Bay; depth $4\frac{1}{2}$ to 8 fathoms; bottom, sand and shells to mud; sea temperature, 7 A.M., 82·8° F.; 5 P.M., 84° F.

Polypus herdmani, n. sp. [201].

STATION XXIII.—Trincomalee, close to Swami Rock, Back Bay; depth $4\frac{1}{2}$ to 8 fathoms; bottom sand, shells, and in places stones and Corals.

Polypus F [207].

STATION XXXIX.—Galle, trawled; from 2 miles south of Point de Galle westwards to Gallehogalle Bank: depth 16 to 30 fathoms; bottom fine sand; stones and Nullipore on the bank.

Sepiadarium kochi [232]. | *Sepia singalensis*, juv. [262–265].

Galle, captured by Professor HERDMAN in the lagoon.

Polypus herdmani, n. sp. [277].

CEPHALOPODA.

SUB-ORDER: OCTOPODA

FAMILY: POLYPODIDÆ.

Polypus herdmani, n. sp.—Plate I.

The Body is comparatively small, purse-shaped, considerably wider behind than at the margin of the mantle; there is no groove on the ventral surface. The mantle

opening is very wide, extending more than half-way round the body, and ending a short distance below and behind the eyes. The siphon is comparatively short, extending rather less than half-way to the umbrella margin.

The Head is comparatively small, and the eyes but slightly prominent.

The Arms are long and stout, on an average nearly four times as long as the body. The umbrella is moderately developed; it is narrowest between the two dorsal arms, somewhat broader between the two ventral, and between the lateral arms about equal to the length of the body. The suckers are of moderate size and closely packed; the first four are in a single series, the remainder in two series.

The Surface is wrinkled by folds, probably due to contraction in spirit. It bears a large number of prominent warts or tubercles; on the back, these are for the most part elongated antero-posteriorly, and the skin around them is thrown up into a series of radiating folds; four of these are arranged at the corners of a rhombus with its long axis in the median line, a little distance behind the eyes, and about a dozen others are distributed more or less irregularly on the posterior part of the back. There are also a number of these elongated warts on the proximal portion of the dorsal and dorso-lateral arms. There are two or three very minute warts above and behind the eye.

The Colour is a dull brownish-grey, paler below. At the base of the ventro-lateral arm, about one-third of the distance between the eye and the edge of the umbrella, is a large eye-like spot, about 13 millims. in diameter, consisting of a pale centre surrounded by a broad dark ring; this in its turn is surrounded by a narrow pale ring, again succeeded by a narrow dark one.

Dimensions of Specimen No. 277.

		Millims.
Length, total		550
End of body to eye		95
Breadth of body		58
,, head		47
Eye to edge of umbrella, between dorsal arms		50
,, ,, ,, ,, lateral ,,		80
Length of first arm	Right 316,	Left 228
,, second arm	,, 356,	,, 316
,, third arm	,, 330,	,, 330
,, fourth arm	,, 356,	,, 285

Localities:—Galle, caught by Professor Herdman in the lagoon. One specimen, female [277].

Station XIX., Palk Bay. One specimen, sex (?) [201].

Station XVI., north of Periya Paar. One specimen, female [216].

Pearl banks, Gulf of Manaar. Five specimens [224, male; 225, 226, female; 228, 229, arms mutilated, sex uncertain].

Station LXV., south end of Cheval Paar. One specimen, sex (?) [231].

The species seems to me sufficiently characterised by the presence of the peculiar ocellar spot near the base of the ventro-lateral arm, which is presented with more than usual constancy in all the specimens of the series recorded above. A few minor modifications which occur in the different individuals may be recorded as a means of indicating the amount of variation in the species.

In specimen 201, measuring 10 millims. from the hinder end of the body to the eye, the skin is comparatively smooth, three of the four warts forming the lozenge on the back can be made out; there are a few small warts around the eye, especially on the left side, and the bases of the dorsal arms are granular. In the left ocellus the pale ring is elevated above the general surface, and the pale spot in the centre also forms a raised papilla.

Specimen 216, measuring 10 millims. from the end of the body to the eye, is very firm and shrivelled, and appears at some time to have been allowed to dry up. The four warts on the back are very distinct, and some of the ridge-like warts on the bases of the arms are also visible.

Specimen 224, measuring 10 millims. from the end of the body to the eye, is somewhat more developed than Nos. 225 and 226 found with it. The ocellar spot on the left side is very distinct, but in the centre is a minute black point instead of a pale patch. The four warts, arranged at the angles of a lozenge, are present, as well as some on the bases of the arms. There is also a wart above and behind each eye.

Polypus arborescens, n. sp.—Plate II., figs. 8, 9 and 12, and Plate III.

The Body is rounded, oblong, usually ending in an acuminate point behind; the mantle opening is narrow, extending only about one-third the distance towards the eye from the siphon, which is short and truncated, and reaches only one-third from the mantle opening towards the margin of the umbrella.

The Head is about as wide as the body, and the eyes are only slightly prominent.

The Arms are on an average about twice as long as the body, measured from the posterior end to the eye; those of the fourth pair are the largest, the first the shortest. The umbrella extends up them rather more than one-third their length. The suckers present no unusual characters, the first four are in a single row, both in a specimen with the arms strongly bent outwards and one in which they are nearly parallel. The hectocotylus is of the form usual in the genus, with a very small tip.

The Surface presents a number of branched papillæ, which constitute the most characteristic peculiarity of the species and suggested its specific name. One of these, larger than the others, occupies the acuminate posterior extremity of the body above alluded to; there are one or two over each eye, about a dozen on the back, a few on the ventral surface, and in most cases one or two on the outer aspect of each arm.

They vary somewhat both in size and arrangement. An account of their minute structure will be found below.

The Colour is a dull grey with irregular, oval ring-like markings on the dorsal surface and the bases of the arms.

Localities :—Station II. or III., west of Ceylon. Three specimens [213–215].

Cheval Pearl Banks, Gulf of Manaar. Six specimens [212, 239–243].

Station XVI., on Periya Paar ; depth 9 fathoms. One specimen [217].

I am not acquainted with any other species at all resembling this one in its surface decoration.

The fact of the proximal suckers being in a single row, not only in arms which are bent outwards, but also in those which are straight, is of some interest. The arrangement of these suckers has often been made use of as a specific character, but has always appeared to me to be of very doubtful validity, because there is no doubt that in many instances it varies with the curvature of the arm. The present instance suggests that it may have more value than I have hitherto supposed.

Structure of the Branched Papillae.

The Papillæ vary a good deal in dimensions. An average one (Plate II., fig. 8) would be 0·75 millim. high by 0·4 millim. in diameter, whilst a large one (Plate II., fig. 9) would attain 1·65 millims. in height by 0·6 millim. in diameter. Each consists of a stem and branches, both of which are plentifully bestrewn with chromatophores. Between the larger papillæ are small ones of various degrees of complexity ; some are simple, some bifurcated, some with three or more branches. Papillæ of the smaller kinds are found on the bases of the arms.

The Stem is conical in form, arising gradually from a broad base. In the smaller papillæ (Plate II., fig. 8) the stem remains unbranched to the apex and there gives rise to branches, from two or three to about half a dozen in number. In the larger (Plate II., fig. 9) the branches are given off at intervals from near the base. Sometimes the apex is seen to persist independently of the branches ; in other instances there is no definite apex, but the stem divides into a tuft of branches at the top. The apex sometimes presents a yellowish appearance as though a yellow internal mass were shining through the integument.

The Branches are almost cylindrical, tapering only very slightly towards the tips, which are bluntly rounded off. Their diameter varies from 0·03 millim. at the tip to 0·15 millim. at their junction with the stem, and their length from 0·8 millim. to 0·25 millim. In most cases they are simple, but in a few instances they bifurcate (Plate II., fig. 8), and still more rarely trifurcate (Plate II., fig. 9).

When a series of sections is examined, it is found that in those taken near the base, just above the muscles of the body wall, there is in the centre a mass of tissue (Plate III., fig. 1, *cm.*) from 0·21 millim. to 0·24 millim. in diameter. It stains but

faintly and presents the appearance of a number of delicate fibrils twisting about in all directions and leaving spaces in which nuclei are situated, though no definite cell boundaries can be distinguished (fig. 4, *c.m.*). The nuclei measure about 0·0058 millim. in diameter, and nucleoli can be seen in them. This central mass rises as a rounded lump to a height of about 0·18 millim.

The greater part of the centre of the stem is made up of a peculiar radially arranged supporting tissue, which stains very deeply with hæmatoxylin. In sections near the base of the papilla this tissue appears as a ring around the central mass and consists of very thin radiating fibres (Plate III., figs. 1 to 4, *r.*), which are collected together in masses forming little trabeculæ, which arise from the surface of the central mass and pass outwards, slightly diverging from each other and leaving clear spaces between them. The rounded spaces at the outer ends of the trabeculæ are occupied by bundles of fibres, which run parallel with the axis of the stem: transverse sections of these bundles are seen in fig. 4, *b.* The trabeculæ stain a deep purple with hæmatoxylin, and thus are in marked contrast with the central mass. They present a number of ovoid nuclei intercalated here and there among the fibres. Above the central mass this axial structure occupies the centre of the stem (compare figs. 1 and 2), and rises up to a height of about 0·7 millim., when it gradually merges into the other tissues of the stem. This axial supporting tissue is produced into the branches, but here it has the appearance of irregular transverse septa (fig. 6, *r.*) with spaces between. The septa are not separate, but continuous with the adjacent ones on either side, owing to their curved form and to connecting pieces passing from one to another. Towards the tip of the branches this tissue becomes less abundant and merges into the surrounding connective-tissue. In the stem this axial tissue is seen to be supplied with blood vessels (fig. 4, *bl.*), but I have not succeeded in detecting any nerves in it.

Around this central column is a layer of connective-tissue (figs. 1 to 3, *c.*) varying from 0·05 millim. to 0·02 millim. in thickness. This is of a loose open nature, with delicate fibrils and numerous large lacunæ; small ovate or spheroidal nuclei are scattered in it here and there. This layer extends into the branches, in the larger of which it is about 0·03 millim. in thickness (fig. 5, *c.*), and gradually disappears towards the tips. Within this connective-tissue layer are the chromatophores and another granular element to be described below.

The chromatophores (*ch.*) are situated in the outer layers of this connective-tissue, either immediately below the epithelium or not very far removed from it. They have the form of little sacs, on an average about 0·035 millim. in diameter. Very often there is a vacant space immediately below the chromatophores (figs. 4 and 13, *l.*). Where the section passes tangentially through the wall of a chromatophore the pigment is seen to be composed of minute granules (fig. 12, *ch.*).

In the connective-tissue layer are also seen here and there masses of substance staining of a paler and more reddish colour than the other tissues and of homogeneous

granular nature (figs. 5, 7, *g.*). This substance is highly refringent and, as above mentioned, stains a pale reddish colour with hæmatoxylin and pale yellow with picronigrosin. I thought at first that it might perhaps be muscular, but on further examination it appeared to consist of rounded masses not fibrils, and at present its nature and function seem to be quite uncertain. It does not appear in the basal portion of the papilla, but commences about halfway up the stem, and is most abundant in its distal portions and in the stouter branches, where it sometimes occupies quite a large proportion of the transverse section (fig. 5, *g.*), and I think it is the cause of the yellowish appearance of the apex mentioned above. It extends in gradually decreasing amount along the branches, but ceases some distance from the tips (figs. 7 and 8). Towards the tips of the branches the various component tissues gradually disappear, leaving only the connective-tissue and epithelium (fig. 8).

The epithelium covering the papillæ (figs. 1 to 9, *ep.*) consists of a single layer of cells, and is about 0·02 millim. in thickness. The cells are of rounded quadrangular outline and have large spheroidal nuclei.

In relation with the epithelium are certain peculiar spherules (Plate III., figs. 9 to 13), the nature of which seems to me very problematical. There are between 15 and 20 of these arranged in a ring around the stem of the papilla quite close to its base. They are irregularly placed, sometimes in a single row, sometimes in two, and they vary in diameter from 0·034 millim. to 0·05 millim. Very few of them come to the surface, and I was unable to find any trace of them by surface examination. I am inclined to think that the different appearances presented by these bodies indicate developmental stages, and I will therefore first describe what seems to be the most complete form.

The central part of the organ consists of a cylindrical plug (figs. 9 to 13, *p.*), the outer end of which is almost on a level with the surface of the epithelium, the other extremity penetrating somewhat below it. The outer end is slightly convex, the inner appears to merge gradually into the tissue beneath. In transverse sections the plug is oval, the diameters being 0·03 millim. and 0·025 millim.; the length of the plug cannot be measured exactly, owing to its fusion with the other tissues at the lower end, but it may be taken at about 0·035 millim. The composition of this plug is faintly granular and almost homogeneous; it shows traces of breaking up here and there into fragments by transverse lines, but this is probably an effect of shrinkage. Below the plug and sometimes apparently rising up around it is a mass of tissue of a flattened spheroidal shape (*m.*). The plug fits into a depression in the outer surface of it, and its lateral expansions support the superficial epithelium. In the only longitudinal section I have of one of these structures (fig. 10) the diameter of this lower portion is 0·065 millim., and its depth below the epithelium 0·021 millim. approximately. In this longitudinal section it appears granular and faintly stained like that of the plug, but there is a distinct tendency for the granules to be arranged in layers (figs. 10, 11, *m.*). In sections at right angles to this the structural arrangement

is concentric with the plug. Definite layers cannot be made out, but portions of greater and less density alternate with each other (figs. 12, 13, *m.*). In some instances I was able to make out a nucleus either in the plug itself or in the subjacent granular tissue. This spheroidal mass has no definite boundary, but gradually passes over into the connective-tissue lying beneath the epithelium.

The epithelium covering the surface of the papilla undergoes a modification in the neighbourhood of these organs. For a little distance around, the cells become columnar instead of cubical, and their nuclei long and attenuated instead of spheroidal (compare figs. 11 and 13). It seems probable that this is due to a compression caused by the plug pushing its way to the surface from beneath. The cells closely surrounding the plug are even more flattened, so as to form an envelope round the sides of the plug, and often to extend inwards a little way below the general lower surface of the epithelium (fig. 9), so that a section parallel with the surface shows them as a ring surrounding the plug, and in their turn encircled by the granular mass (fig. 12, *ep.*).

The upper surface of the plug shows a dense deeply stained boundary, outside which is sometimes a thicker more faintly stained layer (fig. 10), and from this arises a bunch of radiating fibres (figs. 10, 11, *f.*). These are extremely thin, straight, and many of them have slight swellings at the end. They are about 0·06 millim. in length, and their diameter too small to be measured by any appliances at my disposal; it is certainly less than 0·0015 millim. Generally they appear quite discrete, but in one section there seemed to be a delicate transparent substance connecting their tips, and spreading out beyond their extremities into a sort of thin cloud. I did not observe this in any other sections and conclude that it is in some way due to artificial causes.

It is only some half-dozen of these organs which present the appearance just described, that is to say, which come up to the surface and give off a tuft of fibrils. The remainder are completely covered by the epithelium, and hence I conclude they are similar bodies in course of development, which have not yet reached the surface.

The nature of these bodies seems to me very obscure; the different possibilities are as follows:—In the first place they may be parasitic; the radiating tuft of fibrils with thickened ends suggests an Acinetan, but against this are to be set the following considerations: these bodies appear to originate from within and not from without, there is no definite boundary between them and the surrounding connective-tissue, and their granular substance does not resemble the cell contents of the Protozoa.

Assuming that they belong to the Cephalopod, there seem to be difficulties in the way of referring them to any recognised type. The possibility of their being either glandular or phosphorescent seems to be excluded by the tuft of radiating fibrils, whilst against a sensory function must be urged the fusion of their lower portion with the surrounding tissues and the fact that no nerves have yet been traced to them. On the whole, this last view would seem to present less difficulty than the others, and it

may, therefore, be adopted as a working hypothesis. Dr. ASHWORTH has called my attention to their similarity to the lateral organs of Annelids, described by EISIG ('87) and himself (:01).

With respect to the function of the papilla as a whole, the most plausible explanation appeared to me that they are protective. In the spirit specimens they are not altogether unlike the tentacle-bearing heads of polyps, such as *Hydractinia*, and I thought they might furnish the Octopus with a disguise to assist it in concealing itself. Professor HERDMAN, however, tells me that this theory does not agree with his observations on the living animal, which he kept for some time in a small tank. Under these conditions "the papillæ do not look at all like polyps; they are contractile and are kept frequently moving—uncoiling to a considerable length and then curling up again suddenly."

Polypus aculeatus (D'ORBIGNY); GOODRICH ('96)—Plate II., figs. 10 and 13.

Localities:—Pearl Banks, Gulf of Manaar, Cheval district. Ten specimens [197, male (?); 218–221, female; 266, male; 276, female; 630–632, sex (?)].

Station LVI., half-a-mile east of Dutch Modragam. One specimen, sex (?) [200].

. The coloration of these young specimens so closely resembles that of D'ORBIGNY'S species (*Octopus aculeatus*) that I feel but little hesitation in referring them to it. This identification is confirmed in most instances by the presence of small tubercles arising from the centre of the pale circular patches on the upper surface. The general appearance of these examples is shown in Plate II., fig. 13.

Specimen 197 was very small, only 5 millims. in length from the end of the mantle to the eye; the patches were indistinct and no tubercles were visible, so that the determination is less certain than in the other cases.

Specimen 266 was the largest, and measured 15 millims. from the hinder end of the body to the eye. The hectocotylised arm (Plate II., fig. 10) had apparently been mutilated and subsequently repaired. It is normal up to within 2 centims. of the extremity; there it becomes swollen up (*a*) and the suckers suddenly cease; the groove on the ventral aspect (*b*) runs out on the surface where the suckers should be and stops abruptly, about 5 millims. beyond the gap in the series of suckers. From this point there grows out a new tip, quite normal in appearance and about 10 millims. long (*c*). A new groove (*d*) has been formed, starting from a point a little beyond the place where the original groove ceases and quite disconnected from it, and the usual spud-shaped extremity has been formed at the apex of the arm (*e*). This reproduction is of special interest by reason of its rarity. STEENSTRUP ('56, p. 107, footnote) was of opinion that the hectocotylised arm was never replaced, and that consequently the animals exercised special care in order to prevent injury to it. The examination of this specimen further raises the interesting question: If the function of the groove be to transmit the spermatophores, could this action be carried out in the event of the groove being interrupted?

Specimen 276, measuring 9 millims. from the hinder end to the eye, has many characters in common with the others above mentioned, but the colouring is much darker; the papillæ in the centres of the rounded areas are black instead of pale, and there are also black papillæ on the outer aspect of the proximal half of the arms. At present it seems to me most likely a melanic example of *Polypus aculeatus*, but it may perhaps be the young of some undescribed species.

Polypus boscii (Lesueur).

Localities :—Pearl banks, Gulf of Manaar, Cheval district. Three small specimens [271, male; 272, female; 274, male].

This species has hitherto only been recorded from the Australian region. Specimens 272 and 274 are characteristic examples of the var. *pallida*, first obtained by H.M.S. 'Challenger' (Hoyle, '86, p. 81, plate I.).

Polypus macropus (Risso) (?); Goodrich ('96).

Localities :— Station II. or III., West Ceylon. One young specimen [230, female].

Pearl banks, Gulf of Manaar, Cheval district. One specimen [275, male].

Two small specimens, 11 millims. and 8 millims. in length from the end of the body to the eye respectively, may be the young of this widely-distributed species.

Polypus granulatus (Lamarck); Hoyle ('86); Goodrich ('96).

Localities :—Station II. or III., West Ceylon. One young specimen, sex (?) [195].

Station LXV., south end of Cheval Paar. One specimen, sex (?) [211].

Pearl banks, Gulf of Manaar, Cheval district. Three specimens [222, 223, 238].

Station XVIII., Palk Bay, south-east of Catchetivo Island, 7 fathoms. Two specimens [268, 269].

Specimen 195, measuring 8 millims. from the end of the body to the eye, is paler in colour than usual and has a double row of small chromatophores along the outer surface of each arm.

Specimen 211, measuring 12 millims. from the end of the body to the eye, I thought at first must be a male, in which the hectocotylisation was just beginning; it has a slight ridge along the ventral aspect of the third right arm, but no modified tip is to be seen. I have, however, since seen similar ridges on several different arms.

Polypus, juv., A—Plate II., fig. 1.

A number of small Octopods, averaging 5 millims. in length from the hinder end of the mantle to the eye, agree in having a smooth body, long slender arms, connected by a very delicate umbrella extending 4 millims. to 6 millims. from the base, a double row of small dark chromatophores on the outer surface of each arm, and a conspicuous patch of them on the under surface of the mantle.

Locality :—Pearl banks, Cheval neighbourhood, Gulf of Manaar. Five specimens [233–237].

Polypus, juv., B—Plate II., fig. 4.

A smooth form, with very prominent eyes and a few scattered granules on the upper surface.

Locality :—Station LVI. (?), half-a-mile east of Dutch Modragam, second haul. One specimen, sex (?) [244].

Polypus, juv., C—Plate II., figs. 2 and 5.

The specimens enumerated below all appear to me to be the young of one and the same species, which it is just possible may be *P. granulatus* (Plate II., fig. 2). Their most conspicuous characters are a plump, rounded body, short arms, with a rudimentary umbrella between them, a slight but distinct granulation on the back and between the eyes; there is a single row of rather large pale chromatophores on the outer surface of the arms, and one or more bands of them run along the under surface of the mantle parallel with the opening (fig. 5).

Localities :—Station L. (?), pearl banks, Cheval Paar, 4.3.02. One specimen [196].

Station XVIII., Palk Bay, S.E. of Catchetivo Island, 7 fathoms. One specimen [199].

Station II. or III., West Ceylon Two specimens [203, 204].

Pearl banks, Cheval neighbourhood, Gulf of Mánaar. Fifteen specimens [247–261].

Polypus, juv., D—Plate II., fig. 11.

A young form, 10 millims. in length from the hinder end of the mantle to the eye, with a short, rounded body, prominent eyes, with a small wart over each, long slender arms (25 millims. to 30 millims. in length), united by a broad umbrella (10 millims. in breadth, except between the dorsal arms, where it is much less), two irregular rows of small chromatophores along the outer surface of each arm, and a conspicuous patch of chromatophores on the ventral surface. There are two or three moderate-sized warts on the back and a number of small ones on the broad portion of the upper arms. The measurements are taken from specimen 227.

Locality :—Pearl banks, Cheval neighbourhood, Gulf of Mánaar. Two specimens [227, female ; 267, male].

This form agrees with that which I have marked A in the conspicuous patch of chromatophores on the ventral surface and the rather wide, delicate umbrella, but it differs in the presence of well-marked warts over the eyes, and in the chromatophores on the arms being much less delicate and regular. I think they are the young of distinct species.

Polypus, juv., E.

This specimen, 6 millims. in length from the hinder extremity to the eye, has a roughish surface, small warts over the eyes, and two rows of chromatophores widely separated along the outer surface of the arms, which are of moderate length (10 millims. to 12 millims.).

Locality :—Station II., off Chilaw, west of Ceylon. One specimen, sex (?) [202].

This form differs from the one marked A in being more granular, in having small but distinct warts over the eye, and in the arms being comparatively shorter and with a much smaller web.

Polypus, juv., F—Plate II., fig. 6.

This young specimen, 7·5 millims. from the hinder end to the eyes, has the upper surface slightly granular, more markedly so between the eyes, and to some extent on the upper and outer surface of the umbrella and between the dorsal arms. There are two small indistinct warts above each eye; the colour is a dull purplish-grey, paler below. There are two rather irregular rows of chromatophores along each arm and a few large ones scattered on the under surface. The arms are subequal and about 15 millims. in length. This species differs from the last-named in the granular surface of the upper part of the head and body, and in the fact that the chromatophores are absent on the hinder extremity and much smaller and less abundant on the inferior surface of the mantle.

Locality :—Station XXIII., off Trincomalee. One specimen, sex (?) [207].

Polypus, juv., G—Plate II., fig. 3.

Two young examples, 6·5 millims. and 7·5 millims. in length from the hinder end to the eyes, agree in a general resemblance to those marked C, but the chromatophores on the arms are in two rows, with a very narrow line between them (fig. 3), and on the under surface they are evenly distributed instead of being collected in a band along the opening of the mantle. The arms are short, 10 millims. to 12 millims. in length, measured from the eye.

Localities :—Cheval Paar. One specimen, sex (?) [194].

Station II., off Chilaw, west of Ceylon. One specimen, sex (?) [208].

Polypus, juv., H.

These two specimens, like those just mentioned, closely resemble the series marked C; they have a single row of chromatophores on the outer aspect of each arm, but the arms are much longer in proportion, measuring 10 millims. to 12 millims. in comparison with a body length of 5 millims. There is a minute wart over each eye.

Locality :—Gulf of Manaar. Two specimens [209, 210].

Polypus, juv., J—Plate II., fig. 7.

Two specimens, 5 millims. and 6·5 millims. in length of body respectively, agree in having a curious mottled and variegated surface. The smaller is decidedly darker than the larger. Here and there on the body are rough irregular warts, and it is just possible that they might be the young of *Polypus arborescens*. I do not think this is so, as I should have expected the branched warts to be more developed in a specimen of the size of No. 206.

Locality :—Station II., off Chilaw, west of Ceylon. Two specimens, sex (?) [205, 206].

SUB-ORDER : DECAPODA.

FAMILY : SEPIOLIDÆ.

Inioteuthis maculosa, GOODRICH ('96).

Locality :—Pearl Banks, Cheval neighbourhood, Gulf of Manaar. One specimen, female [198].

Euprymna morsei (VERRILL).

Locality :—Pearl Banks, Cheval neighbourhood, Gulf of Manaar. One specimen, female [245].

The *Inioteuthis morsei* of VERRILL (**'81**, p. 417); see HOYLE (**'86, :04**); STEENSTRUP (**'87**); GOODRICH (**'96**).

Sepiadarium kochi, STEENSTRUP.

Locality :—Station XXXIX. (?), two miles south of Point de Galle. One specimen, male [232].

The researches of APPELLÖF (**'98**) on this species and allied forms seem to me to justify his action in classifying it with *Sepiola* and *Rossia* rather than with *Sepia* and *Loligo*, as maintained by STEENSTRUP.

FAMILY : SEPIIDÆ.

Sepia rouxi, FÉRUSSAC and D'ORBIGNY (**'35**).

Locality :—Station I., off Negombo, first haul of trawl, 31.1.02. One specimen, female [246].

Sepia singalensis, GOODRICH.

Localities :—Pearl Banks, Gulf of Manaar. One specimen, female [270]. Station XXXIX., two miles south of Point de Galle. Four specimens, female [262–265].

Specimens 262–265 are, I think, the young of the same species, but I was not able to make out with certainty the suckers on the buccal membrane.

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EXPLANATION OF PLATES.

PLATE I.—*Polypus herdmani*, n. sp.

Fig. 1. Dorsal view of the type specimen. Natural size.

PLATE II.

Fig. 1. *Polypus* A. Natural size.
,, 2. ,, C. ,,
,, 3. ,, G. The second arm on the left side, to show the double row of chromatophores. × 6 diameters.
,, 4. ,, B. Natural size.
,, 5. ,, C. Ventral surface to show the rows of chromatophores parallel with the margin of the mantle. × 5 diameters.
,, 6. ,, F. ,, ,, ,, arrangement of the large chromatophores on the ventral surface. × 5 diameters.
,, 7. ,, J. Two specimens. × 2 diameters.
,, 8. ,, *arborescens*, n. sp., one of the medium sized branched papillæ. × 43 diameters.
,, 9. ,, ,, ,, ,, larger branched papillæ. × 43 diameters.
,, 10. ,, *aculeatus*, tip of the hectocotylised arm of specimen 266. × $2\frac{1}{2}$ diameters.
,, 11. ,, D. Ventral surface to show the patch of large chromatophores. × 3 diameters.
,, 12. ,, *arborescens*, n. sp., specimens in various attitudes to show the branched papillæ. Nat. size.
,, 13. ,, *aculeatus*, specimens showing the characteristic surface markings. Natural size.

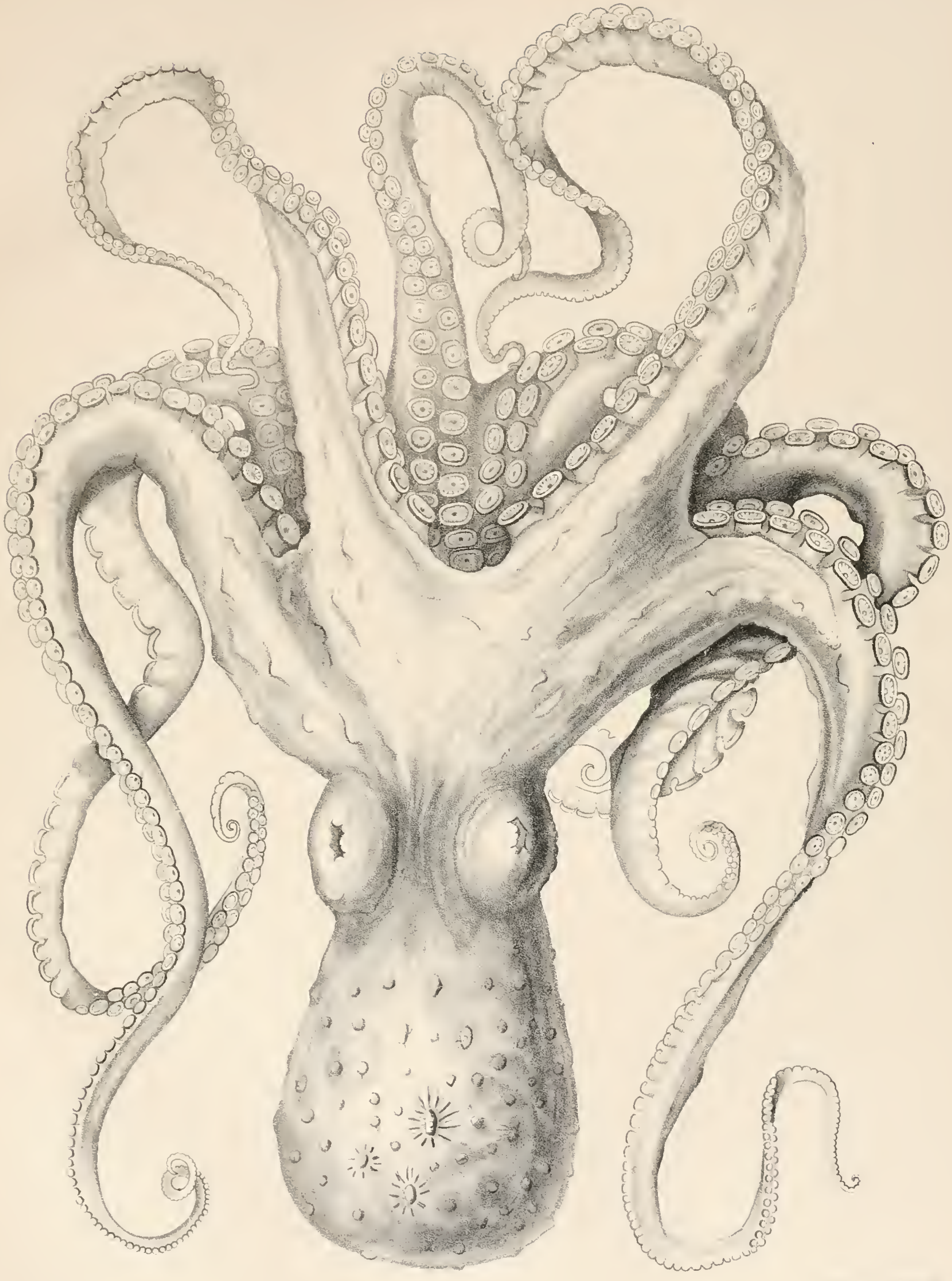
Figs. 1, 2, 4, 7, 12 and 13 are from photographs.

PLATE III.—Papillæ of *Polypus arborescens*, n. sp.

Fig. 1. Section near the base of a papilla. × 38.
,, 2. ,, somewhat higher up. × 38.
,, 3. ,, taken where the lateral branches begin. × 38.
,, 4. A portion of a section such as fig. 1, extending from the central mass to the outside. × 286.
,, 5. Section through a branch, showing a large amount of granular material. × 250.
,, 6. Longitudinal section of one of the thicker branches. × 250.
,, 7. Section through one of the thinner branches. × 286.
,, 8. ,, close to the tip of one of the branches. × 286.
,, 9. Diagrammatic vertical section of one of these organs. × 286.
,, 10. Section at right angle to the surface through one of the epithelial organs. × 430.
,, 11. Oblique section, showing the nucleus. × 430.
,, 12. Horizontal section, taken at the level *A*, *B* in fig. 9, showing the central plug, with layer of epithelial cells and connective-tissue around this again. × 430.
,, 13. A similar section, taken somewhat lower down, at the level of *C*, *D*, fig. 9. × 430.

Explanation of Letters.

b., bundles of fibres parallel to axis of papilla.
bl., blood vessels.
c., connective-tissue.
ch., chromatophores.
c.m., central mass.
ep., epithelium.
f., bunch of fibrils, radiating from the surface of the epithelial organs.
g., granular tissue.
l., lacunæ.
m., mass of granular tissue in epithelial organs.
n., nuclei.
or., organs in the epithelium.
p., central plug of granular material in epithelial organs.
r., radiating connective-tissue fibres.



E. R. Dust del.

POLYPUS HERDMANI, n. sp.

W. E. ... et phot.

E. Wilson, Lith Cambridge

P[illegible]LYPUS.

E. Wilson, Lith. Cambridge

PAPILLÆ

REPORT

ON THE

MARINE FISHES

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

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ZOOLOGICAL DEPARTMENT, UNIVERSITY OF LIVERPOOL.

[WITH TWO PLATES AND TWO FIGURES IN THE TEXT.]

THE collection of fishes made by Professor HERDMAN in the Gulf of Manaar and elsewhere around Ceylon contains 117 species belonging to 73 genera. One species, *Salarias furcatus*, is now described for the first time. Several other specimens obtained are also of much interest. A series of stages, including the adult female, of ALCOCK'S *Psettylis ocellata* were obtained, and, since the original description of this species was based on immature specimens, I have been enabled to revise both generic and specific diagnoses. *Solea oculus*, ALCOCK, of which only two specimens have hitherto been obtained, has also been taken by Professor HERDMAN. An undescribed immature form, belonging apparently to the genus *Scatophagus*, which has previously been found off the coast of Patani, in the Malay Peninsula, was also collected.

DAY (**5**), in his revision of Indian Fishes, records about 1010 marine fishes from Indian seas, and ALCOCK (**4**) subsequently gave an additional list of 202 species, mostly deep-sea forms, which were not recorded by DAY. The present collection, therefore, contains about one-tenth of the species known to inhabit the Indian area. The Gulf of Manaar, however, has a more abundant piscine fauna than the present list represents. E. THURSTON (**10**), in a survey of the pearl banks in this area, collected 107 fishes and, owing apparently to the different method of collection adopted, only 16 species are common to the two lists. The total number of fishes obtained from the Gulf of Manaar is therefore 202.

Twelve species in the present collection are now recorded from Indian shores for the first time. These are:—

Monacanthus tomentosus (L.).—Gulf of Manaar.
Hippocampus villosus, GÜNTHER.—At Station LIV., south of Adam's Bridge.
Solenostoma paradoxum, PALL.—Gulf of Manaar.
Opichthys timorensis, GÜNTHER.—At Station LIV., south of Adam's Bridge.
Platycephalus asper, CUV. and VAL.—At Station XX., Trincomalee.
Arnoglossus spilurus, GÜNTHER.—Common.
Pseudocheilinus hexatænia, BLEEKER.—South of Galle.
Pegasus volans, LINN.—At Aripu Reef.
Aploactis aspersa, TEMM. and SCHLEG.—South of Adam's Bridge.
Erythrichthys leucogrammicus (BLEEKER).—Cheval Paar.
Apogon encastigma, RÜPPELL.—At Aripu Reef.
Apogon septemstriatus, GÜNTHER.—At Station XLIV., south-west of Ceylon.

The classification and nomenclature used by DAY have been adhered to for the most part in the following list, with such changes as have been necessitated by the works of GÜNTHER and ALCOCK.

PISCES.

ELASMOBRANCHII.

CARCHARIIDÆ.

Carcharias, sp.

A fœtus, about 14 inches long, which was taken from an unidentified shark, about 5 feet in length, caught in the Gulf of Manaar.

TORPEDINIDÆ.

Narcine timlei (BL. SCHN.)

Two specimens, largest about 6 inches long. Palk Straits.

TRYGONIDÆ.

Pteroplatea micrura (BL. SCHN.).

A small specimen, about 13 inches across the disc. Pearl banks off Aripu.

MYLIOBATIDÆ.

Dicerobatis eregoodoo, RUSSELL.

A large female was taken at the south end of the Periya Paar; the disc was 38 inches long and the tail about 13 inches. A fœtus was taken from this fish which is about 12½ inches across the disc; the disc is about 8 inches and the tail about 14½ inches long.

TELEOSTEI.

SCLERODERMI.

Monacanthus choirocephalus (Bleeker).

Two specimens from pearl banks off Aripu.

Monacanthus setifer, Bennett.

One specimen from the Aripu pearl banks. The skin is velvety and the "pile" is markedly higher on the body between the second dorsal and anal fin than elsewhere. The dorsal spine has 4 very prominent barbs on either postero-lateral margin, and each of these barbs bears a fleshy tentacle which is leaf-like and serrated on both edges. There are somewhat similar tentacles on the body.

Monacanthus tomentosus (Linn.).—Plate I., fig. 2.

Height of body (including ventral spine, but not including dorsal spine) $\frac{1}{2}$ of the total length; dorsal spine about $4\frac{1}{2}$ in the total length; diameter of eye about $\frac{1}{2}$ the length of the dorsal spine. Eyes above and in front of the gill slits.

Radial formula: D. 27; A. 27; P. 12; C. 12.

Dorsal spine with 4 rows of barbs directed downwards. The 2 anterior rows are closer together than the posterior ones, about 5 barbs in each row. A number of smaller barbs irregularly arranged at the base of the spine. Ventral spine very rough with numerous spinules, 6 of which are larger than the rest and are arranged round the base of the spine. A thick membrane joins the spine to the ventral body wall.

Lateral line with two obtuse angles.

The ground colour (in spirit) is light brown, with dark longitudinal, but rather irregular bars.

Skin velvety to the touch, covered with minute spines.

One immature specimen, 1·4 inches long, was found in the Gulf of Manaar.

Triacanthus brevirostris, Temm. and Schleg.

One specimen from pearl banks off Aripu.

Ostracion turritus, Forsk.

One specimen from Aripu.

Ostracion punctatus, Bl. Schn.

One specimen from Trincomalee.

Ostracion nasus, Bloch.

A number of immature specimens ($\frac{1}{2}$ inch and less in length) were taken at Galle, Station XX.

Balistes stellatus, LACÉPÈDE.

Skin of specimen about 17 inches long. Galle.

GYMNODONTES.

Tetrodon margaritatus, RÜPPELL.

One specimen, about $2\frac{1}{2}$ inches long, from Aripu.

Tetrodon lunaris, BL. SCHN.

Numerous immature specimens from Aripu, also one specimen, 6 inches long, which was taken on a line in the Gulf of Manaar.

SYNGNATHIDÆ.

Syngnathus longirostris (KAUP).

Two specimens about $7\frac{1}{2}$ inches long.

Ichthyocampus carce, HAM. BUCH.

One immature specimen from south of Galle.

Gastrotokeus biaculeatus (BLOCH).

One specimen, 6 inches long, from Gult of Manaar.

Hippocampus villosus, GÜNTHER.

Two specimens were obtained which I refer to this species. They differ slightly from GÜNTHER'S description: the groups of filaments on the tubercles are more dendritic than is represented in his figure. There are about 45 body rings present; the dorsal fin has 16 rays; the length of the snout, which was equal to the distance between the lens of the eye and the gill opening in GÜNTHER'S specimen, is less in the Ceylon ones, so that the snout appears somewhat shorter. The species, however, are most probably the same.

Two specimens, 1·9 inches long, at Station LIV. (south of Adam's Bridge).

Hippocampus guttulatus, CUVIER.

Two specimens from Station LIV. (south of Adam's Bridge).

SOLENOSTOMIDÆ.

Solenostoma paradoxum, PALL.

One specimen, about $3\frac{3}{4}$ inches in extreme length, from the Gulf of Manaar. The colours, in alcohol, are light orange on the body and crimson on the tips of the fins and on the eyes. The specimen is a female, and has a brood pouch containing both eggs and newly hatched larvæ. Mr. HORNELL has since found a specimen covered with arborescent filaments (and with radial formula:—D. 5, 19; A. 21; P. 25; V. 7; C. 16; and two elongated black marks on front dorsal fin) which may be a distinct species.

MURÆNIDÆ.

Muræna picta, Günther.

One specimen from Galle Lagoon.

Opichthys timorensis, Günther.

Two eels, about $9\frac{1}{4}$ inches long, were obtained on Station LXV. (west of Cheval Paar), which appear to belong to this species. The dorsal and anal fins are very low, almost absent; the former begins immediately above the gill slits, the latter a little distance behind the anus. The tail is a little longer than the body; the head is contained 7 times in the distance between the snout and the anus; the body is lumbriciform. The teeth are small and pointed; there are 2 rows on the vomer and a single row in the upper and lower jaws. The coloration is almost uniform (in spirit), yellowish, with brown granular dots on the back.

CHIROCENTRIDÆ.

Chirocentrus dorab (Forsk.).

One specimen, about $12\frac{1}{2}$ inches long, from Palk Strait.

CLUPEIDÆ.

Engraulis commersonianus (Lacépède).

A number of specimens, about 3 inches long, from pearl banks off Aripu.

Clupea fimbriata (Cuv. and Val.).

From pearl banks off Aripu.

Pellona indica, Swainson.

From pearl banks off Aripu.

SCOMBRESOCIDÆ.

Belone, sp.

A young fish, about $\frac{9}{10}$ inch long, found in the Gulf of Manaar, is referred to this genus. The characters of the young differ so much from those of the adults, that it is hardly possible to determine the genus with accuracy. The jaws are not prolonged, and the caudal is truncated. The dorsal fin has 23 rays and the anal 22.

SCOPELIDÆ.

Saurus indicus, Day.

Galle; very numerous; also Palk Bay.

Saurus myops (Forsk.).

Galle; very numerous.

Saurida tumbil (Bloch).

Galle and Aripu ; very numerous.

Saurida nebulosa (Solander).

One specimen was dredged $\frac{3}{4}$ mile north-north-west of Foul Point, Trincomalee, Station XXIV.

SILURIDÆ.

Freshwater fishes were not collected, so that this family is only slightly represented.

Arius venosus, Cuv. and Val.

Three specimens, the largest of which is about 12 inches long, were obtained at Station XVII., on the pearl banks off Aripu.

PLEURONECTIDÆ.

Flat fishes are, as might be expected, very well represented in this collection. Eight genera and 16 species altogether were collected.

Psettodes erumei (Bl. Schn.).

Numerous specimens up to 14 inches long were obtained from the pearl banks off Aripu. This species appears to be indifferently sinistral and dextral. The single specimen examined was sinistral.

Pseudorhombus arsius, Bleeker.

Numerous specimens, varying in length from 12 inches downwards, were collected from Station II., near Negombo, and from the pearl banks off Aripu.

Solea oculus, Alcock.

The only specimen belonging to this genus was obtained in Palk Bay, Station XIX. It agrees in every particular with the beautiful species obtained by Alcock (3) in Bengal Bay, 32 miles south-west of Puri. It is $3\frac{1}{10}$ inches in extreme length. The depth of water it was obtained from is curiously enough exactly that (7 fathoms) recorded by Alcock.

Synaptura cornuta, Cuv.

One specimen, about 5 inches in extreme length, was obtained in deep water (25 to 30 fathoms) off Galle, Station XLVI. There are 14 dark bands on the ocular side which are perfectly parallel and transverse to the long axis ; each is darker at its margins. The anterior thickened first ray of the dorsal fin is markedly on the blind side. The pectoral fins are short and thickened ; their bases are covered with

small scales, and they are continuous with the upper margin of the opercular fold. The scales are peculiar; the projecting margins are thickly covered with skin, and on the head, on the blind side of the body, these integumentary margins become thicker and might be regarded as short tentacles. The scales are continued on both sides of the body for a short distance into the gill cavities.

Psettyllis pellucida, Alcock.

Palk Bay, 3 specimens, 1·3 inches to 1·6 inches.

Psettyllis ocellata, Alcock.

Palk Bay, 7 specimens, 1·6 inches to 2·2 inches, and a mature female, 4·7 inches long—the latter is figured (Plate I., fig. 3) as only an immature stage was known.

Note on the genus **Psettyllis.**—Plate I., fig 3, and Plate II.

Psettyllis was created by Alcock (1) in 1890 for the reception of a number of Pleuronectids allied to *Rhomboidichthys* which he obtained off the Ganjam and Vizagapatam coasts in 7 to 13 fathoms of water. Alcock entertained the possibility that these forms might be "larval or stunted" flat-fish; but in the relative proportions of the body, the completed symmetry, the unilateral restriction of the pigment, the perfect ossification of the skeleton, the slight unilateral atrophy of the paired fins, and the character of the vertical fins, he saw indications of development which warranted generic and specific discrimination. Many of these characters are not, however, absolutely diagnostic of completed development; the ossification of the skeleton, for instance, is already almost perfect in very small plaice, and some pigmentation of the blind side would appear to be quite a normal feature in some tropical species of Pleuronectidæ, in some species of *Arnoglossus* for instance. Study of the specimens of *Psettyllis* obtained by Professor Herdman in Palk Bay affords conclusive proof that the forms described by Alcock as *P. ocellata* are certainly, and that those described as *P. pellucida* are probably, immature.

The 8 specimens of *P. ocellata* (Plate II., figs. 3 to 8) form a natural series and have the following characters in common:—(1) The pigmentation, in so far as the form and distribution of the ocelli are concerned: there is a most characteristic ocellus behind the lateral line elevation and a number of differently shaped ocelli on the body and vertical fins; (2) the lateral line: there is a peculiar elevation above the pectoral fin on the ocular side, which presents two almost right angles; and (3) the scales: the surface of the body is covered with small cycloid scales, but close to the bases of the dorsal and anal fins on the ocular side there are one or more rows of ctenoid scales.

Two of these specimens belong to the stage figured and described by Alcock. The general surface of the body is colourless; the eyes are separated by an inter-orbital space equal to 1·7 times the major diameter of the eye; the scales are very

small and are apparent only on a microscopical examination of the skin; the ctenoid scales along the fin margins are just indicated; and the ratio of the height of the body to the length (exclusive in both cases of the fins) is 0·73 : 1.

Five specimens differ slightly from the above. The general surface of the body is pigmented (brownish in spirit); the interorbital space is nearly equal to the major diameter of the eye; the ctenoid scales along the fin margins are very evident; and the ratio of the height to the length of the body in the largest is 0·69 : 1.

The single large specimen (Plate II., fig. 3) is 4·7 inches in total length. It is a female with ripe ovaries. The interorbital space is nearly equal to the major diameter of the eye. The ratio of the height of the body to the length is 0·65 : 1. The length of the head is contained $4\frac{2}{3}$ times in the total length, the tail $5\frac{1}{2}$ times; the length of the maxilla is contained $3\frac{1}{2}$ times in the length of the head. The upper ray of the pectoral fin on the ocular side is elongated and is nearly $\frac{1}{3}$ of the total length. The scales are cycloid, except for several rows along the fin margins on the ocular side, which are strongly ctenoid. They are very small, and there are about 80 in the lateral line. The jaws are slightly, and the teeth markedly, asymmetrical. The cleft of the mouth is twisted dorsally on the blind side and on that side the teeth are strongly developed, there being several rows in both jaws. On the ocular side there are also several rows of less strongly developed teeth. Teeth are absent on the vomer and palatines.

The radial formula is: D. 96; A. 69; P. 8; V. 6; C. 17.

The dorsal fin begins on the snout on the blind side. The positions of the ventral fins are markedly asymmetrical.

The anus is situated on the blind side and the urinary opening on the ocular, in both cases some little distance from the ventral margin of the body.

ALCOCK's definition of the genus must then be amended. The body is sub-circular (in the young); jaws and dentition asymmetrical; length of maxilla more than $\frac{1}{4}$ of the length of the head; eyes on the left side separated by a broad concave space; dorsal fin commencing on the snout; its rays and those of the anal simple; scales small, those on the general body surface cycloid, but along the bases of the dorsal and anal fin strongly ctenoid; lateral line with an angular elevation above the pectoral fin; the latter with its upper ray (sometimes) elongated.

The genus is closely allied to *Rhomboidichthys*, and *Psettyllis ocellata* to *Rhomboidichthys ocellatus*, AGASSIZ. Some species of *Rhomboidichthys*, *i.e.*, *R. podas* and *R. mancus*, possess spinous scales along the fin margins, and in many others the pectoral fin may be elongate. *Psettylis*, however, seems to differ in the following characters: (1) cycloid scales on the general surface of the body and (2) the asymmetrical jaws and dentition.

It is not improbable that *Psettyllis pellucida* may be the young of some form belonging to another genus; at any rate, the characters given by ALCOCK are probably not those of the adult.

Cynoglossus arel (Bl. Schn.).

Two specimens of this fish were obtained, the longest of which is about 15 inches in extreme length. Day's figure of this species is very unsatisfactory and shows too many scales in the longitudinal diameter. Palk Bay, Station XVIII., soft mud, 7 to 8 fathoms.

Cynoglossus brachyrhynchus (Bleeker).

Pearl banks off Aripu.

Cynoglossus hamiltoni (Günther).

Pearl banks off Aripu.

Cynoglossus brevirostris, Day.

Pearl banks off Aripu.

Cynoglossus oligolepis (Bleeker).

Cynoglossus bengalensis (Bleeker).

One specimen from Palk Bay, Station XVIII. Also from Station IV., off Chilaw, about 4 inches in extreme length.

Cynoglossus, sp.

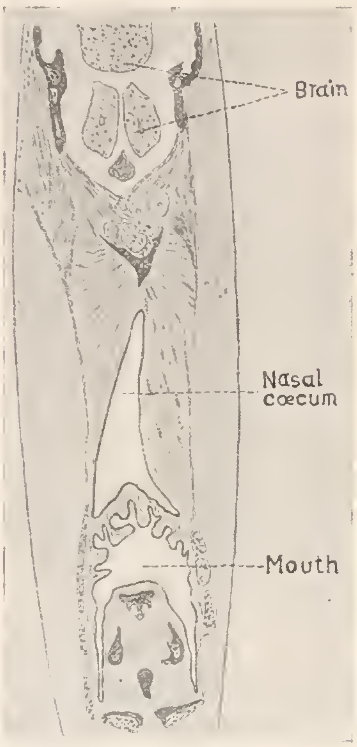
A single specimen was obtained which is unfortunately in a bad state of preservation, most of the scales on both sides being rubbed off. The extreme length is $1\frac{1}{3}$ inches, but the specimen is a mature female, the ovaries being largely distended on both sides. The colour is reddish-violet towards the margins of the body. The scales on both sides are coarsely ctenoid. The small size at sexual maturity is extraordinary, but we know little of the rate of growth of tropical Pleuronectids. Station XXV., off Foul Point, Trincomalee, 8 fathoms.

Note on "Naso-pharyngeal" Communications in *Cynoglossus.*

Kyle, in 1900 (**9**), gave a description of a communication between the nose and mouth in a species of *Cynoglossus*—*C. semilævis*, Günther. This was found in one specimen out of five examined and is considered by the author to be a structural detail of considerable morphological importance. A number of specimens of *Cynoglossus* were found in working over the present collection, and another from the Patani coast, several were dissected and serial sections were made of others. The following species were examined in this way: *C. arel*, *C. bengalensis*, *C. macrolepidotus*, *C. brachyrhynchus*, and *C. brevirostris.* In none of these specimens were any traces of a naso-pharyngeal communication to be found.

A nasal cœcum was found in every fish examined. This structure answers to the

description given by KYLE; text-fig. 1, which is part of a transverse section through the head of a young specimen of *C. bengalensis*, shows the relations of the nasal cœcum to the mouth. It is a large thin-walled sac, triangular in transverse section, lying dorsally to the mouth and only separated from the latter by the buccal epithelium and its own wall. It extends backwards for a considerable distance. Anteriorly it is formed, as KYLE's figures show, by the union of two lateral, relatively narrow canals, one proceeding from each olfactory sac. These pass downwards and fuse together over the roof of the mouth.



Text-fig. 1. Transverse section through head of *Cynoglossus bengalensis*. × about 12 diameters.

The perforation joining the cavity of this sac with that of the mouth lay apparently in KYLE's specimen about the middle of the length of the cœcum.

The occurrence of this opening in only one specimen of a number examined suggests that it is quite abnormal, and most probably the result of an accident. In one specimen, *C. brevirostris*, which was cut into serial sections, a Copepod parasite possessing convoluted egg sacs was found in the cœcum. Several other larger specimens were then dissected, and in one of these (*C. brachyrhynchus*) a single Copepod parasite was found, which is described in Part I. of this Report (p. 294) as *Chondracanthus cynoglottidis*, THOMPSON and SCOTT. The anchor hooks of this Copepod were embedded in the muscles outside the dorsal wall of the cœcum, and its body lay on the thin ventral wall, so that it was immediately apparent on opening the buccal cavity sufficiently to show the roof of the mouth.

The occurrence of this Copepod in such a situation suggests what is doubtless the real explanation of the naso-pharyngeal communication—that is, that the perforation was an injury due to this or a similar parasite. Either the body and egg sacs resting on the thin ventral wall of the cœcum had produced the rupture of the latter, or the anchor hooks had themselves become embedded in this part of the wall and, as the parasite increased in size, broke through it. With such an origin the perforation would have no morphological significance whatever; and the speculations of its discoverer on the origin of the internal nares of vertebrata, which are based on its occurrence, are therefore without real value.

Rhomboidichthys azureus, ALCOCK.

Two specimens answer to the description of this species, except that the number of

scales on the lateral line is 58 to 60 instead of about 55, the number counted by ALCOCK.

Galle, Station XXXIX., 16 to 30 fathoms, on a bottom of fine sand. The area from which this fish was obtained had a very rich fish fauna; about 1350 specimens were trawled belonging to the following species:—*Rhomboidichthys azureus*, *Arnoglossus spilurus* (very abundant), *A. macrolophus*, *Callionymus longicaudatus*, and *C. sagitta*.

Arnoglossus spilurus, GÜNTHER.

A large number of specimens of a species of *Arnoglossus* were collected, the characters of which correspond almost entirely with those of the above species, which was first found by the "Challenger" in the Arafura Sea.

The dorsal fin has about 86 rays, and the anal 63 to 68.

There are 48 scales in the lateral line. The upper ray of the pectoral fin is greatly enlarged in the males (in some cases, however, the sex is difficult to determine on account of the immaturity of the specimens). In most cases the extreme length of this elongated ray is two-thirds of the height of the body. There is a pointed knob on the anterior part of the maxilla on the ocular side. The blind side of the body is of a uniform smoky-grey colour (in spirit).

Size, $1\frac{1}{3}$ inches to $3\frac{1}{2}$ inches in extreme length. From the pearl banks off Aripu; Galle; south of Cheval Paar; and south of Adam's Bridge. Common.

Arnoglossus macrolophus, ALCOCK.

A mature female, about $2\frac{3}{4}$ inches in total length, is apparently this species. The first few rays of the dorsal fin are more elongate than the others. The radial formula is D. 85; A. 65; L.L. 55. Off Galle, Station XXXIX.

OPHIDIIDÆ.

Fierasfer homei, RICHARDSON.

Two specimens, 4 inches and $4\frac{1}{2}$ inches long, were obtained south of Adam's Bridge, Station LIV. I refer them to *Fierasfer homei*, though they differ in a few respects from the descriptions of that species. The head is contained $6\frac{1}{2}$ times in the total length and its breadth is one-half of its length. The greatest depth of the body is $10\frac{1}{2}$ in the total length.

There are several rows of teeth in the upper jaw, the external of which are the strongest; several teeth on either side of the symphysis are larger than the rest. On the vomer there are three large teeth forming a median ridge.

The colour (in spirit) is yellowish, with a row of stellate markings above and below the lateral line on each side.

ALCOCK (2, p. 44), observed cases of commensalism between *F homei* and *Stichopus* in the seas of the Laccadive and Andaman Islands.

LABRIDÆ.

Platyglossus hyrtlii (Bleeker).

Several specimens, about 4 inches long, from pearl banks off Aripu.

Pseudocheilinus hexatænia, Bleeker.

One specimen, about $1\frac{3}{4}$ inches long, was obtained from south of Galle, Station XLI.

GLYPHIDODONTIDÆ.

Amphiprion sebæ, Bleeker.

Two specimens, the largest of which was about $3\frac{1}{2}$ inches long, were taken off Aripu.

Pomacentrus jerdoni, Day.

Numerous specimens, about 2 inches to $2\frac{1}{2}$ inches long, were obtained off Aripu.

Pomacentrus cyanopsilus, Bleeker.

Two specimens, about 2 inches in total length, were collected. The colours in spirit are: dorsal, anal, and pelvic fins dark brown, a dark brown spot at the superior margin of the base of the pectoral.

There are light blue spots on the scales on the head and cheeks, above the pelvic and anal fins, and underneath the dorsal. The scales on the rest of the body have each a blue vertical line.

D. 12/13, A. 2/13; height of body $2\frac{1}{8}$ in total length.

Pomacentrus bankanensis, Bleeker.

One specimen from the Pearl Bank, Station VI., uniform blackish-brown in spirit, with the exception of the caudal, which is yellow. There is a dark spot on the operculum near the origin of the lateral line.

CENTRISCIDÆ.

Amphisile scutata (Linn.).

Very numerous off Aripu; 2 inches to $5\frac{1}{4}$ inches long.

The number of fin-rays in the dorsal and caudal fins appears to be very constant; the number in the anal varies from 12 to 14, and in the pectoral from 9 to 11.

BLENNIIDÆ.

Petroscirtes breviceps (Cuv. and Val.).

Three specimens from south of Adam's Bridge, Station LIV., and also from Cheval Paar.

Petroscirtes lienardi, Day.

One specimen from south of Adam's Bridge. It has no tentacles on the cheeks, but there are two unfringed ones on the lower jaw.

Petroscirtes cyprinoides (Cuv. and Val.).

Three specimens from off Mutwal Island.

Salarias alboguttatus, Day.

Three specimens of this Blenny were taken off Muttuvaratu Paar. The largest is nearly 2 inches long. They appear to belong to the above species, but differ in some respects. The radial formula is: D. XII. 17; A. 19; V. 2; P. 11; and the dorsal fin is deeply notched.

There are 8 or 9 broad dark bands (in spirit) with narrow interspaces descending from near the dorsal fin to the lateral line. The ground colour is light yellow. There is a short tentacle over the anterior part of the orbit.

Salarias furcatus, n. sp.—Plate I., fig. 4.

The head is contained $5\frac{1}{3}$, the height of the body $6\frac{3}{4}$, and the extreme length of the caudal 4 times in the total length.

Radial formula: D. XI., 17; A. 18; P. 13; V. 2; C. 24.

The dorsal fin is very faintly notched, but the membrane between the last spine and the first ray is wider than elsewhere in the fin; two portions are about the same height; the soft dorsal does not extend on to the caudal. The caudal is deeply forked, two of the outer rays being prolonged. The arrangement of the rays is: 1–6, **7**, 8–15, **16**, 17–24, beginning with the extreme dorsal ray; the rays outside the prolonged rays are very small.

The head is without a crest; there are two simple tentacles, one long and the other short, on each side of the head in front of the orbit.

The teeth in both jaws are movable and comb-like. Canines are absent.

The colour (in spirit) is nearly uniform blackish-brown; there is a black blotch on the dorsal fin between the first and third spines.

One specimen, 2·4 inches long, from Chilaw Paar, Station LXIX., on a bottom of sand and coral.

The diagnostic feature of the species is the deeply concave caudal fin.

CALLIONYMIDÆ.

Callionymus longicaudatus, Temm. and Schleg.

From Galle.

Callionymus sagitta, Pall.

From Galle.

A fish egg obtained in one of the tow-nettings had all the characters of the eggs of the British Callionymi. Its diameter was, unfortunately, not measured, but the reticulations on the shell are well shown in Mr. Hornell's drawing.

GOBIIDÆ.

Gobius griseus, DAY.

From Palk Bay, Station XIX.

Gobius viridipunctatus, CUV. and VAL.

Two specimens, about $\frac{1}{2}$ inch in length, were taken. These have numerous rows of wart-like protuberances, not only on the cheeks, opercula, and head, but also on the pelvic fins, the rays of the latter being covered by them. Galle reef.

Gobius masoni, DAY.

South of Cheval Paar, Gulf of Manaar.

Gobius melanosticta, DAY.

One specimen, about 2 inches long, from Gulf of Manaar.

Gobius acutipinnis, CUV. and VAL.

South of Adam's Bridge, Station LIV.

Gobius biocellatus, CUV. and VAL.

South of Cheval Paar, Station XLVII.

Gobiodon citrinus, RÜPPELL.

Several specimens, the largest of which is about $1\frac{3}{4}$ inches long, from Aripu reef.

Periophthalmus kœlreuteri (PALL.).

A number of specimens, about 5 inches long and less, were taken in the mangrove swamps at Trincomalee.

Trypauchen vagina (BL. SCHN.).

A single specimen, about $5\frac{3}{4}$ inches long, was obtained in Palk Strait.

CATAPHRACTI.

Pegasus draconis, LINN.

A number of specimens, about $2\frac{1}{2}$ inches long, were obtained from Aripu reef, south of Cheval Paar, and south of Adam's Bridge.

Pegasus natans, LINN.

One specimen was collected on Aripu reef. This species has apparently been previously recorded only from Chinese and Australian seas.

Pegasus volans, LINN.

One specimen, about 2·1 inches long, was obtained from Aripu reef. The fifth rays of the pectoral fins are greatly thickened. The tail is rather over one-half of the

total body length; the head is contained thrice in the body length; the rostrum is short, about one-sixth of the length of the head.

This species has not been obtained previously from Indian waters.

TRICHONOTIDÆ.

Trichonotus setigerus, Bl. Schn.—Plate I., fig. 7.

Several specimens of this species were obtained from south of Adam's Bridge, Station LIV., north of Cheval Paar Station LII., and outside Periya Paar, Station XVII. The largest is 3·8 inches long, its radial formula is D. 50; A. 40. There are 58 scales in a longitudinal, and $\frac{5}{6}$ in a transverse series. These are almost exactly the numbers given by Alcock (2) for *Tæniolabrus cyclograptus*, and they approximate very closely to the corresponding numbers for *T. setigerus*. The elongated first dorsal rays said to be present in the species are absent in the specimens from Ceylon. They may, however, be broken off, as the fins are in other respects somewhat injured.

Several specimens collected are referred to *T. setigerus* (see Plate I., fig. 7), but differ in possessing fewer rays in the dorsal and anal fins and in the larger size of the scales. They may eventually prove to be a new species.

Radial formula: D. 43; A. 35; P. 13; V.I. 5; C. 13.

Scales: L.l. 51; L.tr. $\frac{4}{4}$.

Length of the head nearly 5, height of the body 14, in total length. Lower jaw protruding, and a knob at the mandibular symphysis. Mouth very wide. Eyes close together.

Colours (in spirit), one specimen reddish-brown (ground colour), the rest colourless; a row of ocelli on the back on each side of the dorsal fin; a black blotch on the commencement of the latter.

Four specimens, $2\frac{1}{2}$ inches to $1\frac{1}{3}$ inches in total length, from Aripu reef, south of Cheval Paar, Station LXII. (on pearl banks), and in Palk Bay.

COTTIDÆ.

Platycephalus tuberculatus, Cuv. and Val.

A number of specimens were taken on Cheval Paar.

Platycephalus insidiator, Forsk.

A single immature specimen from south of Adam's Bridge.

Platycephalus serratus, Cuv. and Val.

One specimen from Station XX., Back Bay, Trincomalee.

Platycephalus punctatus, Cuv. and Val.

Several specimens, 6 inches long and less, from Cheval Paar, Station X.

Platycephalus asper, Cuv. and Val.

A large number of specimens were obtained off Galle. There are 5 preopercular spines present. The upper is the largest, and the next three become successively smaller. The lowest is large and is directed forward.

PEDICULATI.

Antennarius mummifer (Cuv.).

From pearl banks off Aripu. One specimen.

Antennarius marmoratus (Less.).

A single specimen, about 1 inch long, obtained from Galle Lagoon, is most probably a variety of this species. The colour (in spirit) is uniform blackish, with the exception of the tips of the caudal, anal, pectoral, and pelvic fins, which are white. The skin is rough, being covered with minute granules. The first dorsal spine is nearly as long as the second, and has an oval lobe or flap at the free end. D. 3/12; A. 7; P. 9.

Halieuta stellata (Wahl.).

A single specimen, about 1 inch long, from Galle.

TRACHINIDÆ.

Percis punctata, Cuv. and Val.

One specimen from off Mutwal Island.

Percis pulchella, Temm. and Schleg.

Several specimens, about $1\frac{1}{2}$ inches long, from south of Cheval Paar, Station XLVII.

STROMATEIDÆ.

Stromateus sinensis, Euphrasin.

From Palk Strait.

CARANGIDÆ.

Caranx hippos (Linn.).

One specimen, about 8 inches long, from Palk Strait.

Caranx leptolepis, Cuv. and Val.

A number of specimens, about 5 inches long, from the pearl banks off Aripu.

Seriola nigrofasciata (Rüppell).

A single specimen, $1\frac{1}{4}$ inches long.

Equula splendens, Cuv.

Numerous in Palk Bay, Stations XVIII. and XIX.

Gazza equulæformis, Rüppell.

A single specimen, about 6 inches long, from Palk Bay, Station XVIII. The other species of fishes taken at Station XVIII. in Palk Bay were *Gazza equulæformis*, *Equula splendens*, *Psettodes erumei*, *Trichonotus setigerus*, *Sciæna maculata*, *Cynoglossus arel*, *C. bengalensis*, *Pseudorhombus arsius* and *Caranx hippos*.

TRICHIURIDÆ.

Trichiurus savala, Cuv. and Val.

One specimen, 23 inches long, from Palk Strait.

The first pair of teeth in the upper jaw are very large curved fangs, which are received into depressions in the lower jaw, the remaining teeth in both jaws are much smaller and are flattened from side to side, so as to form pointed, cutting instruments.

SCLÆNIDÆ.

Sciæna diacanthus (Lacépède).

One specimen, about 12 inches long, from Palk Strait.

Sciæna maculata (Bl. Schn.).

One specimen, about 7 inches long, from Palk Bay.

TEUTHIDIDÆ.

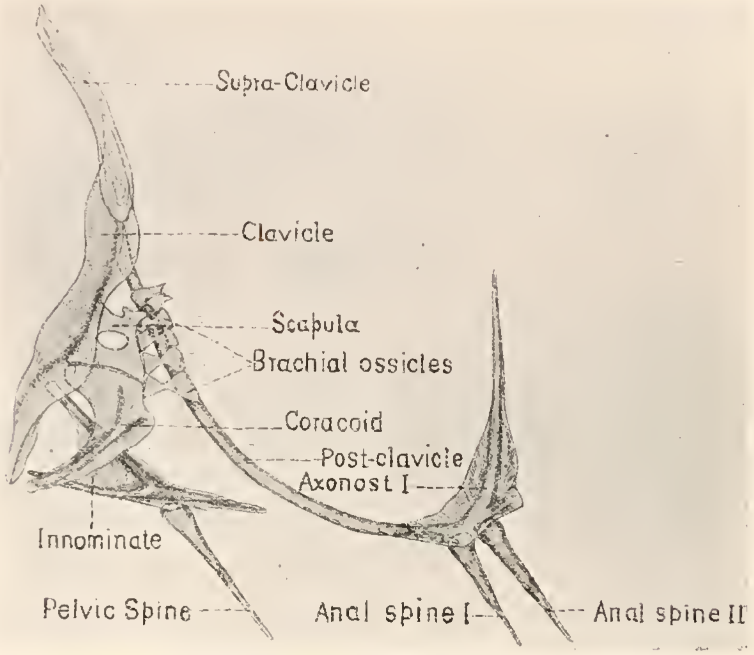
Teuthis oramin, Günther.

A number of specimens from south of Cheval Paar, at Station XLVII.

Note on the Limb Girdles of *Teuthis oramin*.

The limb girdles in the genus *Teuthis* present several interesting peculiarities which have not, so far as I am aware, been figured. Text-figure 2 shows the natural relations of these structures in a specimen about 2 inches long. A faint line is visible in the skin of the fish, extending from above the base of the pectoral fin to the root of the anal. On dissection this is seen to be produced by a curved bony bar, which is obviously the post-clavicle. Its upper extremity articulates with the clavicle near the upper end of the latter. Its lower extremity is connected to the anterior end of the 1st axonost by a strong fibrous bundle. The latter bone is very stout, is strengthened by anterior and posterior ridges, and is grooved on its ventral surface for the reception of the first two anal spines. Scapula and coracoid are quite distinct, but are closely connected; the former has a large fenestra; there are four

brachial ossicles, three of which articulate with the scapula and one partly with this bone and partly with the coracoid. The two upper rays of the pectoral fin articulate



Text-fig. 2. Limb girdles of *Teuthis oramin*. × 4 diameters.

directly with the scapula; the coracoid is a thin bone with an external strengthening ridge.

The two innominates are very closely bound together and lie nearly in the middle line of the body. Each consists of a triradiate bony mass and the two anterior spurs are connected together by a thin bony lamella.

The post-clavicles thus form two subsidiary arches supporting the side walls of the abdominal cavity.

SCORPÆNIDÆ.

Scorpæna haplodactylus, Bleeker.

One specimen, about 3 inches long, and several much smaller ones, were obtained from south of Adam's Bridge.

Scorpænopsis guamensis (Quoy and Gaim.).

Two specimens, about $1\frac{1}{4}$ inches long.

Scorpænopsis cirrhosa (Thunb.).

One specimen, 3 inches long, from Gulf of Manaar.

Scorpænopsis oxycephala (Bleeker).

Numerous, south of Adam's Bridge; Galle; south of Cheval Paar. 2 inches or less in length.

Aploactis aspersa, Temm. and Schleg.—Plate I., fig. 5.

Length of head $3\frac{1}{2}$ inches; height of body $3\frac{1}{2}$ times in the total length. Cleft of the mouth directed obliquely upwards; length $\frac{1}{4}$ that of head. Eyes very small, diameter about $\frac{1}{7}$ of the length of the head. Nostrils, especially the anterior ones, tubular. General shape of head monstrous; prominent preorbital processes; cheeks and opercula with blunt spines and ridges.

Radial formula: D. 4, 19; A. 10; P. 13; V. 4; C. 14.

The first 4 spines of the dorsal fin are separated from the rest; there are about 10 spines following this portion, but it is difficult to determine the exact number; ventrals reduced; caudal rounded.

Skin everywhere covered with blunt, soft tubercles; these are present on all the fins and are especially large and rough on the first portion of the dorsal; 11 large tubercles on the lateral line of one side and 13 on the other.

One specimen, 2·1 inches long, from south of Adam's Bridge.

Pterois zebra, Cuv. and Val.

Pointed nasal tentacles are present. The orbital tentacles are flat and fringed on their posterior margins.

There is a flat tentacle on the premaxilla, near the angle of the mouth, and 3 short ones on the preoperculum.

Two specimens, the largest about 3 inches long, Gulf of Manaar.

Gymnapistus niger (Cuv. and Val.).

One specimen, about 2 inches long, from Periya Paar.

Gymnapistus dracæna (Cuv. and Val.).

A single specimen, about $2\frac{1}{4}$ inches long, from south of Adam's Bridge.

Minous monodactylus (Bl. Schn.).

Two specimens, about $2\frac{1}{2}$ inches long, from south of Adam's Bridge.

Choridactylus multibarbis, Richardson.

A single specimen, $1\frac{3}{4}$ inches long, from south of Adam's Bridge.

CIRRHITIDÆ.

Cirrhitichthys aureus (Temm. and Schleg.).

The free pectoral rays reach to just beyond the anal spines. The 1st dorsal ray is not prolonged. The colour is uniformly red-brown in spirit.

One specimen, about 2 inches long, Gulf of Manaar.

MULLIDÆ.

Upenoides tragula (Richardson).

Several specimens, about 3 inches long, from Aripu and south of Cheval Paar.

SQUAMIPINNES.

Ephippus orbis (Bloch).

One specimen from pearl banks off Aripu.

Scatophagus argus (Gmel.).—Plate I., fig. 1.

A single specimen of an apparently immature fish (Plate I., fig. 1) which probably belongs to this species was obtained by Professor Herdman, but the locality cannot, unfortunately, be traced. It is identical with a Tholichthys-like form which I have described from Patani Bay, Malay Peninsula (8), and which has been identified by Mr. G. A. Boulenger as *Scatophagus argus*. The head is armed heavily with bony plates; the opercular pieces are very massive and carry two strong spines; the radial formula is: D. XI., 18; A. IV., 16; Pect. 16; Pelv. I., 5; C. 26. The skin is covered with minute spines. The number of spines in the dorsal fin was slightly variable in the specimens collected by Messrs. Annandale and Robinson. Mr. Robinson informs me that they were "not uncommon in the Jambu estuary, generally swimming near the surface in companies of three or four."

PERCIDÆ.

This family is very sparingly represented in the present collection.

Apogon ellioti, Day.

Several specimens from Galle, the largest of which is about $2\frac{3}{4}$ inches long.

Apogon eneastigma, Rüppell.

Rüppell obtained this species from Massana, in the Red Sea. The specimens obtained in Ceylon agree closely with his description. D. $7/\frac{1}{9}$; A. 2/8; L. l. 27.

There is a prominent dark, white edged ocellus (in spirit) behind the operculum.

Three specimens from Aripu reef, the largest of which is $2\frac{1}{3}$ inches long.

Apogon septemstriatus, Günther.

This species has been previously taken only by the "Challenger" in the Arafura Sea. The Ceylon specimens agree closely with Günther's description and figure.

The 1st dorsal spine is very small and is absent in some specimens.

A number of specimens, $1\frac{1}{4}$ inches to $2\frac{1}{4}$ inches long, from Galle and south of Adam's Bridge, Station LIV.

Therapon puta, Cuv. and Val.

Several specimens from the pearl banks off Aripu. The average length is about 5 inches.

Scolopsis phæops (Bennett).

A single specimen, $1\frac{3}{4}$ inches long, from Aripu reef.

PRISTIPOMATIDÆ.

Erythrichthys leucogrammicus (Bleeker)—Plate I., fig. 6.

The genus *Erythrichthys* is comparatively rare, and has not hitherto been recorded from the coasts of India. It has been found in Cuba, Molucca, and Sunda seas, Australia, New Zealand, Japan, and Sea of Valparaiso. It appears usually to inhabit open water or rather deep seas.

Height of body almost 6, length of head $4\frac{1}{2}$ in total length; body fusiform; vertical fins terminating some distance from the caudal fin; spines and rays of vertical fins very weak; caudal fin deeply forked; abdomen rounded.

Radial formula: D. IX, V, I, 10; A. III, 10; P. 19; V. I, 5; C. 17.

The first dorsal and anal spines very short; 5 free spines in the dorsal; operculum completely covered with scales; a flat, pointed spine immediately above the origin of the pectoral; inferior angle rounded. Lateral line nearly straight and with 79 scales in a longitudinal row. L.tr. $\frac{9}{19}$.

Teeth completely absent; mouth very protractile.

Colours in spirit, silvery below the lateral line; brownish above, but with a faint crimson band directly above the lateral line.

A single specimen, $3\frac{6}{10}$ inches long, from Cheval Paar in 7 fathoms.

Synagris bleekeri, Day.

Several specimens, $2\frac{3}{4}$ inches long, from off Galle.

Note.—Several species of fishes, in addition to those recorded in the above list, were also observed, and have been identified from the sketches made by Professor Herdman and Mr. Hornell. Several species of *Balistes* are of particular interest, since they form the intermediate host for the *Tetrarhynchus*, which is the parasite concerned in pearl-formation. *Balistes undulatus*, Mungo Park, and *B. mitis*, Bennett, occur, and a third form observed may possibly be *B. erythrodon*, Günther. A large Trygon-ray, in which an adult *Tetrarhynchus* occurred, was sketched by Mr. Hornell, and has been identified by Mr. Boulenger as *Tæniura melanospilos*, Bleeker; also the cockle-eating ray *Ætobatis narinari*, Marcgr. Finally, a species of *Echineis* was caught, which appears to be *E. albescens*, Temm. and Schleg.

I am greatly indebted to Mr. G. A. Boulenger, F.R.S., for much kind assistance in the identification of several doubtful species.

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EXPLANATION OF PLATES.

PLATE I.

Fig. 1. A "Tholichthys" stage: probably the immature form of *Scatophagus argus* (GMEL.). × 4.
„ 2. *Monacanthus tomentosus* (L.), juv. × 3.
„ 3. *Psettylis ocellata*, ALCOCK; mature female; nat. size.
„ 4. *Salarias furcatus*, n. sp. × 1½.
„ 5. *Aploactis aspersa*, TEMM. and SCHLEG. × 1½.
„ 6. *Erythrichthys leucogrammicus* (BLEEKER); nat. size.
„ 7. *Trichonotus setigerus*, BL. SCHN. × ½.

PLATE II.

All the figures are directly reproduced from photographs taken by Mr. A. SCOTT. Figs. 1 and 2 represent two immature specimens of *Psettylis pellucida*, ALCOCK; and figs. 3 to 8 six immature specimens of *Psettylis ocellata*, ALCOCK. The six latter specimens form a series, 3 being the most, and 8 the least immature. Fig. 3, Plate I., represents the mature female of *P. ocellata*.

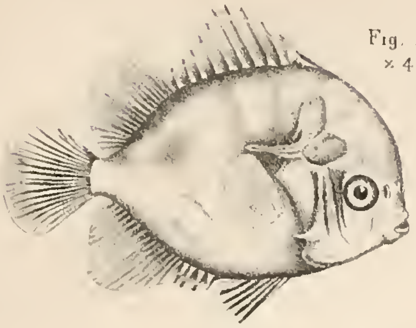


Fig. 1
× 4 *dia*

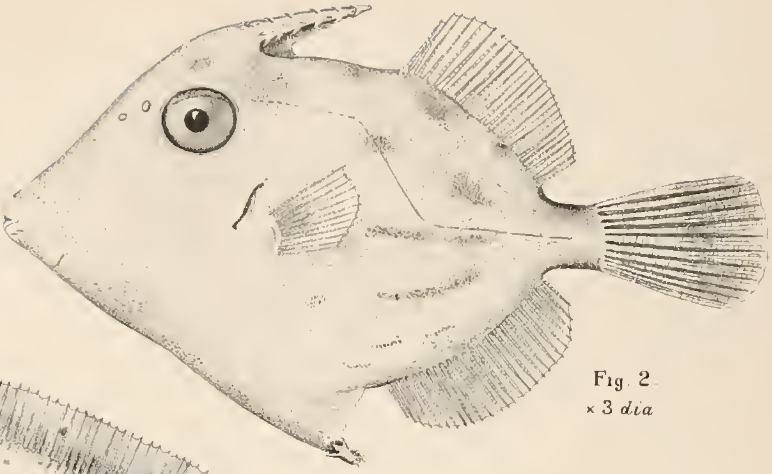


Fig. 2.
× 3 *dia*

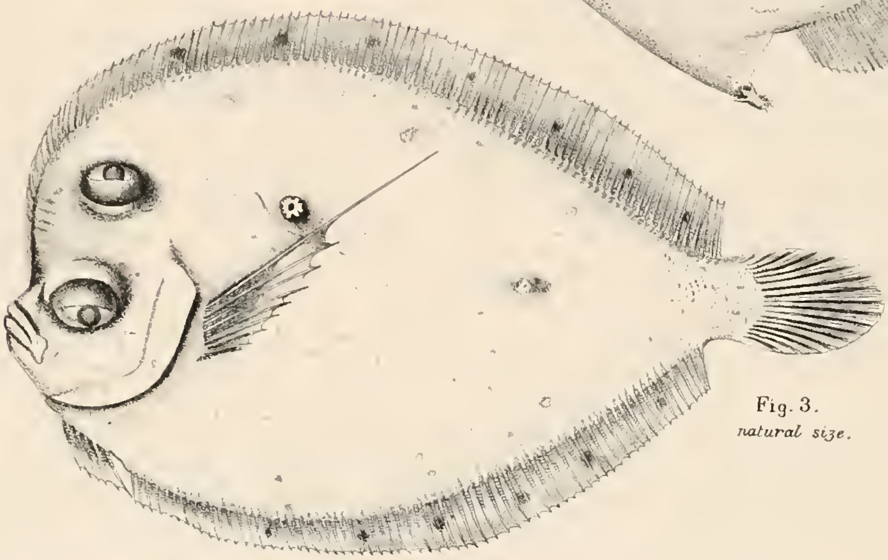


Fig. 3.
natural size.

Fig. 4 × 1½ *dia.*

Fig. 5. × 1½ *dia.*

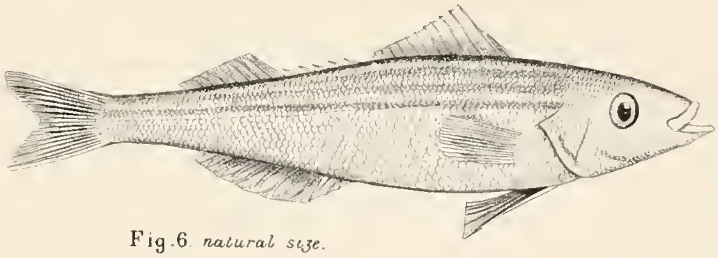


Fig. 6. *natural size.*

Fig 7
× 1½ *dia.*

J J del
Fig 5, S.J.B del

E Wilson, Lith Cambridge

FIG. 1, "THOLICHTHYS" STAGE OF SCATOPHAGUS ARGUS; FIG 2, MONACANTHUS TOMENTOSUS, JUV.; FIG 3, PSETTYLIS OCELLATA; FIG. 4, SALARIAS FURCATUS, N.SP.; FIG. 5, APLOACTIS ASPERSA; FIG. 6, ERYTHRICHTHYS LEUCOGRAMMICUS, FIG 7, TRICHONOTUS SETIGERUS;

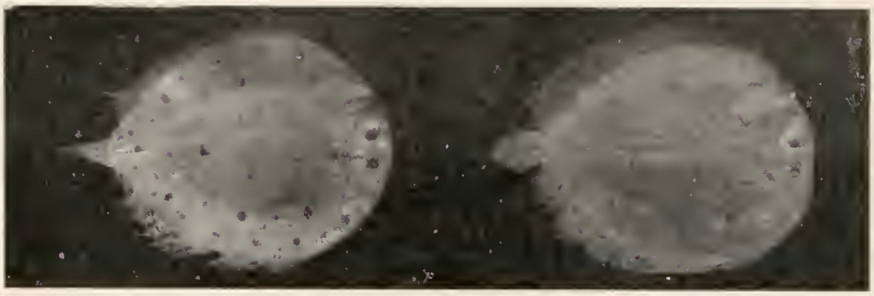


Fig. 1. Fig. 2.

Fig. 3. Fig. 4.

Fig. 5. Fig. 6.

Fig. 7. Fig. 8.

Immature Psettylis.

REPORT

ON THE

CAPRELLIDÆ

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

DR. P. MAYER,
OF THE NAPLES ZOOLOGICAL STATION.

[WITH NINE TEXT-FIGURES.]

THE collection of Caprellids from Ceylon, kindly entrusted to me by Professor HERDMAN, contains nothing of unusual interest. The genera *Metaprotella*, *Monoliropus*, *Paracaprella*, and *Paradeutella* are represented. Of these *Metaprotella* and *Paradeutella* have already been reported from this region,* and exactly the same species have now been found again, viz., *M. excentrica*, *M. problematica*, and *P. bidentata*. *Paracaprella* is represented in the collection by a single female, concerning the specific identity of which I am uncertain. On the other hand, there is no doubt that the species of *Monoliropus* in this collection is new. The genus itself was known before from East Indian waters, but not from Ceylon.

I will first give a list of the species arranged according to the localities at which they were collected, and will then make such remarks as seem necessary on the specimens, and describe the single new species.

LIST OF CEYLON CAPRELLIDÆ FAUNISTICALLY ARRANGED.

Gulf of Manaar, Station LVIII., 10 to 20 fathoms: *Monoliropus falcimanus*, n. sp.
Cheval Paar, shoal buoy, 4 fathoms: *Monoliropus falcimanus*, n. sp.
Pearl Banks, off Aripu, 7 to 8 fathoms: *Monoliropus falcimanus*, n. sp. (?).

* P. MAYER, 'Die Caprellidæ der Siboga-Expedition,' 1903, p. 145.

Gulf of Manaar, Station V., Chilaw Paar, 10 fathoms: *Metaprotella excentrica*, MAYER; *Monoliropus falcimanus*, n. sp.

East of shoal buoy, Pearl Banks, 6 fathoms: *Metaprotella excentrica*, MAYER; *Monoliropus falcimanus*, n. sp.

Kondatchi Paar, 5 fathoms: *Monoliropus falcimanus*, n. sp.

Periya Paar Kerrai, 9 fathoms: *Metaprotella excentrica*, MAYER; *Monoliropus falcimanus*, n. sp.

Muttuvaratu pearl oyster washings, 8 fathoms: *Metaprotella problematica*, MAYER (?); *Monoliropus*, sp. (?).

East Cheval Paar, 6 fathoms: *Metaprotella excentrica*, MAYER; *Monoliropus*, sp. (?).

Cheval Paar, 7 fathoms: *Metaprotella excentrica*, MAYER; *Monoliropus falcimanus*, n. sp.

From pearl oyster washings, East Cheval Paar, 6 fathoms: *Metaprotella excentrica*, MAYER; *Metaprotella problematica*, MAYER; *Paradeutella bidentata*, MAYER; *Monoliropus falcimanus*, n. sp.

Cheval Paar, 8 fathoms: *Paracaprella*, sp. (?)

NOTES ON THE SPECIES.

Metaprotella excentrica, MAYER.

This species, already reported from the East Indies, is represented by specimens from various localities.

A.—From Station V., north end of Chilaw Paar, 10 fathoms. The heads, antennæ, and backs of the larger examples are covered with small mussels. The largest male is over 13 millims. long, and the flagellum of the first antenna has 14 joints; the tubercle at the base of the antenna is very variable. The old males do not possess the pair of spines on the back of segment 3; a younger male, however, possesses it, besides an unpaired spine on the back of segment 2. The only female (with 13 joints in the flagellum) has the same spines as this male, but the pair of spines on segment 2 is very conspicuous; ventro-laterally on the end of segment 4 is an obtuse ridge. The spine at the base of the second antenna in the female is small, and it is entirely wanting in the young males. For the rest, the examples agree well with my former description ('Nachtrag zur Monographie,' 1890, p. 25).

B.—From the East Cheval Paar oyster washings there are some good sized males, one female with eggs in the brood-pouch, and numerous young ones. The large males are provided also on segment 3 with a pair of spines of quite variable length.

C.—From East Cheval Paar, 6 fathoms, the examples all have their hind extremities missing. Of the four females, two carry eggs in the brood-pouch; the pair of spines on segment 3 is not always present.

D.—Periya Paar Kerrai affords only a young female; Cheval Paar, 7 fathoms, only a young male and a young female.

I do not feel quite sure whether the four specimens from East of shoal buoy, 6 fathoms (all of them without the hind legs), also belong to *M. excentrica*, since they seem to be rather clumsier, and their gills rather rounder, than usual. The largest male has 12 joints in the flagellum, and a pair of spines both on the head and segment 2; another male has the same also on segment 3. But evidently they do not belong to any other known species of *Metaprotella*.

Metaprotella problematica, Mayer.

The washings from East Cheval Paar oysters furnish a good many examples of this species which I described in 1890 ('Nachtrag zur Monographie,' p. 26). The largest male is 7 millims. long and has 16 joints in the flagellum of the first antenna; a female, 5·5 millims. long, has a 15-jointed flagellum, and is accordingly older than that which I had formerly described. The palmar edge of the hind legs is not particularly concave; nevertheless it is much more concave than that of *Metaprotella excentrica*, as I correctly supposed.

Very probably the two badly preserved young males from the Muttuvaratu pearl oyster washings belong to *M. problematica*.

Paradeutella bidentata, Mayer.

There are 10 examples from the East Cheval Paar oyster washings. The largest male is not quite 5 millims. long and has 12 joints on the flagellum of the first antenna. One female has on its head a Foraminifer of rather gigantic dimensions relatively to its host.

Paracaprella, sp.?

The locality "Cheval Paar, 8 fathoms," affords a female 4·5 millims. long, and without hind legs, which belongs to the genus *Paracaprella*. The animal is quite smooth. Flagellum of the first antenna 9-jointed. The mandibular palp is represented by only one bristle. The hand of the second leg (= second gnathopod of author's) has no poison-tooth. To which species this female belongs I would not venture to determine.

Monoliropus falcimanus, n. sp.—(Text-figures, p. 226.)

The genus *Monoliropus*, which I founded only a short time ago ('Siboga-Exped.,' 1903, p 53), on examples of the species *M. agilis* from Siam, now is enriched by a second species. Of this new species a good deal of material is furnished from the following localities:—Station LVIII. (5 specimens); Shoal buoy, 4 fathoms (3 specimens); Station V. (4 male specimens); East of shoal buoy, 6 fathoms (14 specimens); Kondatchi Paar (3 quite small specimens); Periya Paar Kerrai (2 female specimens); Cheval Paar, 7 fathoms (30 specimens); and East Cheval Paar oyster washings (12 specimens).

Unfortunately, in most of the specimens the hind legs are lost.

This new species is distinguished from *Monoliropus agilis*, first, by the fact that

the locking spine ("Einschlagdorn") on foot 6 and 7 is not notched terminally as in *Proto ventricosa*, but is simply obliquely truncated. Further, the hand of the second

Fig. 1.	*Monoliropus falcimanus*, n. sp.			Lateral view of nearly adult male; of the hind legs only the last one is represented. × 19.	
,, 2.	,,	,,	,,	Second leg of adult male. × 19.	
,, 3.	,,	,,	,,	,, ,, young male. × 45.	
,, 4.	,,	,,	,,	,, ,, adult female. × 45.	
,, 5.	,,	,,	,,	Mandibular palp	of male represented in fig. 1. × 165.
,, 6.	,,	,,	,,	Maxilliped	of male represented in fig. 1. × 165.
,, 7.	,,	,,	,,	Gill and corresponding leg of young male represented in fig. 3. × 78.	
,, 8.	,,	,,	,,	Gill and corresponding leg of adult female represented in fig. 4. × 78.	
,, 9.	,,	,,	,,	Lateral view of abdomen of male represented in fig. 1. × 78.	

leg of the old male (fig. 2) is sickle-shaped,* while in the oldest-known male of *M. agilis* it is shaped as in the young males and in the females of the new species.

* The *specific* name is based on this character.

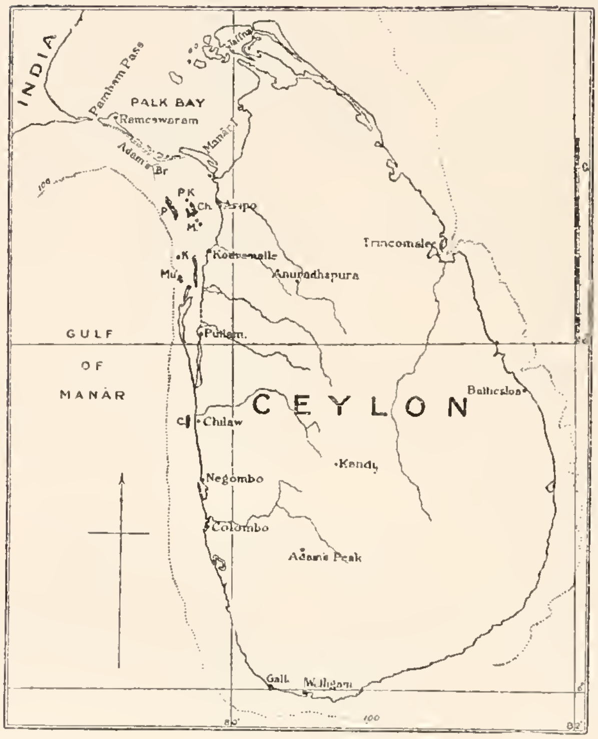
Finally, the penultimate joint of the palp of the maxilliped (fig. 6) is produced into a pointed process, which appears to be occasionally absent, and, at any rate, affords no easily distinguishable characteristic.

The length of the male is about 8·5 millims., that of the female not quite 4 millims. Dorsal surface of body smooth, save that the second segment in the male may bear a pair of very small tubercles anteriorly (fig. 1). Laterally, on segments 2 to 4, short ridges are present anteriorly, which in the female project less strongly, just as in *M. agilis.* First antenna short; flagellum in the male with 9, in the female with 8 joints. Second leg short; arm thin, joints 2 and 3 with a short lateral ridge, which in the old male (fig. 2) is relatively small; joint 4 round. The hand of the male is long, slender and sickle-shaped, its palmar edge covered with long bristles; in females and young males (figs. 4 and 3) it is relatively broader and not sickle-shaped; the locking spine is proximal, the poison-tooth distal, the claw is long. Gills long and slender; the corresponding legs very small in the old males, in the females and young males (figs. 8 and 7) relatively larger and less pointed. Leg 5, in place of the locking spine, has one or two somewhat strong hairs; legs 6 and 7 have one (exceptionally, in old males, two, one after the other) locking spine which is obliquely truncated.

The mandibular palp in the old males has at the end of the third joint a palette and 1 long, 3 small, and 2 middle-sized hairs (studied *in situ*). I give a figure of that of a not quite adult male (fig. 5) and also of the maxilliped (fig. 6). The first maxilla bears on its outer plate 7 hairs.

A profile-view of the abdomen of the male is given in fig. 9.

I am not quite certain whether to this species belong some small and badly preserved specimens from the following localities:—Pearl banks off Aripu (1 female); Muttuvaratu pearl oyster washings (1 female with two large eggs in the brood-pouch); and East Cheval Paar, 6 fathoms (1 young female).



Sketch-map of the Ceylon coast, showing the principal pearl-banks in the Gulf of Manaar, from which most of the specimens were collected. C., Chilaw Paar; Ch., Cheval Paar; K., Karativo Paar; M., Modragam Paars; Mu., Muttuvaratu Paar; P., Periya Paar; P.K., Periya Paar Kerrai.

REPORT

ON THE

AMPHIPODA

COLLECTED BY

PROFESSOR HERDMAN, AT CEYLON, IN 1902.

BY

ALFRED O. WALKER, F.L.S., F.Z.S.

[WITH EIGHT PLATES.]

THE collection of AMPHIPODA made by Professor HERDMAN and Mr. HORNELL on the coasts of Ceylon is undoubtedly the most important that has ever been brought from a tropical sea. It consists of 80 species, of which 36 are new to science. Six new genera have been found necessary for the reception of some of the species. Several interesting forms have been found among them. The new genus *Vijaya* is characterized by a curious difference in the structure of the upper antennæ in the males and females, as is also the case with the remarkable genus *Platyischnopus*, STEBBING, the male of which is now first described. *Gallea tecticauda*, n. gen. and sp., seems to be an abundant form of peculiar structure, being a link between the Amphilochidæ and Leucothoidæ, though I have thought it desirable to place it in the former family. *Cheralia avicula*, again, I have found difficult to place—its affinities are with the Photidæ on the one hand, and the Corophiidæ on the other. So far it has only been found in pearl oyster washings, and as it is probably, from the structure of the last 3 pairs of peræopods, tubicolous, it is possible that it may be confined to these shells.

Two of the species taken, *Hyperia galba* and *Leucothoë spinicarpa*, appear to be cosmopolitan, and as the first is commonly found in Medusæ and the second in Tunicates, it is interesting to note that, possibly from this cause, they show a remarkable power of accommodating themselves to great changes of temperature.

The size of the Ceylon specimens is generally small, even as compared with Amphipoda from our own coasts, while they are pigmies alongside of those from the Arctic and Antarctic seas. The largest measured is 10 millims. long; our own *Amathilla homari* is 25 millims. and some of the Arctic and Antarctic species are still larger.

Two species of different families, viz., *Melita anisochir* and *Cheiriphotis megacheles*, deserve notice from the great size of the "hands" of the 2nd pair of feet (gnathopods) in the males and their resemblance to a broken bit of shell. One would suppose their use to be protective, as they are large enough to cover the animal when half buried in sand, but it is difficult to see why the males only should be so protected; in both instances the females have quite small hands.

The list of areas from which species have been previously recorded is only to be regarded as an indication of distribution and does not pretend to be complete, nor is that of much importance, as the Amphipoda have been so little collected in most seas. Roughly speaking, it may be said that of the Gammaridea 19 species have been recorded from the Northern Hemisphere, 8 from the Southern, and 7 may be considered Equatorial, but it must be remembered that the number of collectors is far greater in the North. The greatest number of individuals taken in this collection belong to the Southern genus *Platophium*.

The Caprellidæ are treated separately, by Dr. PAUL MAYER, in the Report that precedes this in the present volume.

The following Amphipoda were taken by Professor HERDMAN while tow-netting in the Indian Ocean to the south of Sokotra and eastwards towards Ceylon from January 15 to January 18, 1902:—

Vibilia viatrix, BOVALLIUS, 2 specimens;
Paraphronima gracilis, CLAUS, 2 specimens;
Hyperia bengalensis (GILES), several specimens;
Phrosina semilunata, RISSO, 1 young male, length 2 millims.;
Anchylomera blossevillei, M. EDW., a considerable number of specimens;
Sympronoë parva, CLAUS, 1 male specimen.

CLASSIFIED LIST OF SPECIES IN THE COLLECTION.

The capital letters affixed to the names of the species in the list below indicate parts of the coast of Ceylon, as follows:—

(A), south of Karativo to Colombo (Stations I. to V. and LXVI. to LXIX.).
(B), north of Karativo to Kodramallai Point (Stations VI. to VIII. and LVI. to LX.).
(C), north of Kodramallai to Bengalli (Stations IX. to XVII., XLVII. to LII., LV., and LXI. to LXV.).

(D), north of Bengalli (Stations LIII. and LIV.).
(E), south of Colombo (Stations XLII. to XLVI.).
(F), in or near Galle Harbour (Stations XXXV. to XLI.).
(G), in or near Trincomalee Harbour (Stations XX. to XXXI.).
(H), general coast of Ceylon, under 100 fathoms, exact locality not recorded.

The localities and other details of the stations referred to in Roman numerals will be found in the "Narrative," at p. 17, in Part I. of this series of Reports.

Tribe: HYPERIIDEA.

Family: HYPERIIDÆ.

Hyperia galba (Mont.)—(F). Probably cosmopolitan.
H. crucipes, Bovallius—(B). Tropical Atlantic; off Barbadoes (Bov.).
H. bengalensis. Giles—(B). Bay of Bengal.
Hyperoche cryptodactylus, Stebbing—(F). Near Cape of Good Hope.

Family: PHROSINIDÆ (Stebbing, 1888).

Phrosina sp.

Family: SCELIDÆ (Claus, 1879).

Parascelus parvus, Claus—(C). Atlantic Ocean.

Family: LYCÆIDÆ (Claus, 1879).

Elsia indica, Giles—(B) (D). Bay of Bengal.

Tribe: GAMMARIDEA.

Family: ORCHESTIIDÆ.

Hyale nilssoni (Rathke)—(B). Atlantic and Mediterranean; Azores; Sokotra.

Family: LYSIANASSIDÆ.

Ichnopus taurus, Costa—(F). Mediterranean.
Socarnes schmardæ (Heller)—(B). Mediterranean.
Socarnella bonnieri, n. gen. and sp.—(F).
Lysianax cinghalensis, Steb.—(B) (C). Ceylon.
L. calochir, n. sp.—(B) (D).
Orchomenella nana (Kröyer)—(C). Norwegian, British and French coasts.
Tryphosa cucullata, n. sp.—(B).
Vijaya tenuipes, n. gen. and sp.—(H).

FAMILY: PONTOPOREIIDÆ.

Urothoë spinidigitus, n. sp.—(C).

FAMILY: ARGISSIDÆ, nov.

Argissa hamatipes (NORMAN)—(B). Greenland (HANSEN); Norway; Britain.
Platyischnopus herdmani, n. sp.—(C).

FAMILY: PHOXOCEPHALIDÆ.

Leptophoxus uncirostratus (GILES)—(G). Bay of Bengal.

FAMILY: AMPELISCIDÆ.

Ampelisca tridens, n. sp.—(B) (C) (D) (F).
A. scabripes, n. sp.—(A) (C) (H).
A. brachyceras, n. sp.—(B) (C).
A. brevicornis, COSTA—(B) (F). Atlantic; Mediterranean.
A. cyclops, n. sp—(B) (F).
A. chevreuxi, n. sp.—(B) (C).

FAMILY: AMPHILOCHIDÆ.

Amphilochus neapolitanus, DELLA VALLE—(B). Mediterranean; Britain.
Gallea tecticauda, n. gen. and sp.—(B) (C) (D) (F).

FAMILY: LEUCOTHOIDÆ.

Leucothoë spinicarpa (ABILD.)—(A) (B) (C) (F) (H). Probably cosmopolitan; from Greenland to the Azores and perhaps Australia.
L. hornelli, n. sp.—(A) (D) (G).
L. stegoceras, n. sp.—Singapore.

FAMILY: ANAMIXIDÆ (STEBBING, 1898*).

Anamixis stebbingi, n. sp.—(B).

FAMILY: STENOTHOIDÆ.†

Stenothoë marina (SP. BATE)—(C). Norway; Britain; France; Mediterranean.
S. monoculoides (MONT.)—(C) (F). do. do. do. do.
S. gallensis, n. sp.—(B) (C) (F) (H).

FAMILY: ŒDICERIDÆ.

Perioculodes serra, n. sp.—(B) (C).
Synchelidium brevicarpum (SP. BATE)—(C). Britain; Norway.

* 'Ann. and Mag. Nat. Hist.' (7), vol. IV., 1898, p. 210.

† Owing to the connexion between Amphilochidæ and Leucothoidæ shown by *Gallea*, I have placed the latter family before instead of after Stenothoidæ.

Family: SYRRHOIDÆ.

Tiron thompsoni, n. sp.—(B).

Family: CALLIOPIIDÆ.

Eusiroides cæsaris, Steb.—(B) (C) (F). Australia.
E. orchomenipes, n. sp. (?)—(C).

Family: ATYLIDÆ.

Paratylus granulosus, n. sp.—(C).

Family: DEXAMINIDÆ (Stebbing, Ann. and Mag., *loc. cit.*).

Dexamine serraticrus, n. sp.—(A).
Tritata antarctica, Stebbing—(A) (C) (H). Australia.
Guernea lævis, Chevreux—(B) (C). France.

Family: GAMMARIDÆ.

Hornellia incerta, n. gen. and sp.—(B) (C).
Melita obtusata (Mont.)—(A) (C) (D) (E) (G). Norway; Britain; France; Mediterranean.
M. anisochir (Kröyer)—(A) (B) (C) (G) (H). Rio Janeiro.
Mæra othonides, n. sp.—(A) (C) (D) (F) (H).
M. scissimana, Costa—(B) (F) (H). Mediterranean.
M. rubromaculata (Stimpson)—(B) (C) (E) (F). Pacific; Australia; Cape Agulhas.
M. tenella (Dana)—(C). Fiji Islands.
M. tenuicornis (Dana)—(C). New Zealand.
Elasmopus subcarinatus (Haswell)—(A) (B) (C) (D) (F) (G). Australasia.
E. spinimanus, n. sp.—(F).
E. serrula, n. sp.—(C) (F).
E. dubius, n. sp.—(C).
Parelasmopus suluensis (Dana)—(C). North Australia; Sulu Sea.
Cheirocratus sp.—(C).
Megaluropus agilis, Norman—(B) (C). Britain; Holland; Mediterranean.

Family: LILLJEBORGIDÆ (Stebbing, *loc. cit.*).

Lilljeborgia pallida, Sp. Bate—(B) (D) (H). Norway; Britain; France.

Family: AORIDÆ (Steb., *loc. cit.*).

Lembos podoceroides, n. sp.—(B) (C) (D) (G) (H).
L. chelatus, n. sp.—(A).

Family: PHOTIDÆ.

Gammaropsis zeylanicus, n. sp.—(A) (B) (C) (D) (F) (G).
Cheiriphotis (n. gen.) *megacheles* (Giles)—(A) (B) (C) (D). Bay of Bengal.
Photis longicaudata (Sp. Bate)—(B) (C) (F). Norway; Britain; France; Mediterranean.
P. longimanus, n. sp.—(C).
P. nana, n. sp.—(B).
Chevalia aviculæ, n. gen. and sp.—(B) (C).

Family: AMPHITHOIDÆ (Steb., *loc. cit.*)

Amphithoë intermedia, n. sp.—(A) (B) (C) (Station XXXIV.).
A. vaillanti, Lucas—(B). Mediterranean.

Family: ISCHYROCERIDÆ (Steb., *loc. cit.*).

Ischyrocerus anguipes, Kr.—(H). Arctic Seas; Norway.
Jassa, sp.—(B).
Erichthonius abditus (Templeton)—(A) (B) (C) (F). European coasts; Azores.
E. macrodactylus (Dana)—(D). Sulu Sea.

Family: COROPHIIDÆ.

Cerapus calamicola (Giles)—(C) (D) (H). Bay of Bengal; Australia; Sokotra.
Siphonœcetes orientalis, n. sp.—(A) (B) (D).
Corophium crassicorne, Bruzelius—(C). Jan Mayen; Norway; Britain; France.

Family: DULICHIDÆ.

Platophium læve (Haswell)—(A) (B) (C). Australia.
P. synaptochir, n. sp.—(B) (C) (F).
P. zeylanicum, n. sp.—(C).

Family: COLOMASTIGIDÆ (Steb., *loc. cit.*).

Colomastix pusilla, Grube—(B). Britain; France; Mediterranean.

DESCRIPTION OF THE SPECIES.

The following terms are used in the description :—

"Pleon" = Metasome, G. O. SARS; the first 3 abdominal segments.

"Urus" = Urosome, G. O. S.; the last 3 abdominal segments.

"Ocular lobe" = Lateral angle of the head.

"Appendage" = Secondary or accessory appendage of the upper antennæ.

In the peduncle of the antennæ the "first joint" is the ante-penultimate; in the limbs it is the basipodite, the propodos, or hand, thus being the 5th joint.

The measurements are from the tip of the uropods to the base of the antennæ when the Amphipod is laid straight.

When a joint is said to be as long as two or more it means as long as those joints united.

In the following classification the system used by Professor G. O. SARS in his 'Amphipoda of Norway' has been followed, except as to the position of the genus *Leucothoë*.

TRIBE: HYPERIIDEA.

FAMILY: HYPERIIDÆ.

Hyperia, LATREILLE, 1825.

Hyperia galba (MONT.).

Two from the Reef, Galle, the largest 7·5 millims.

The serration of the hind margin of the 1st gnathopod is simple, as figured by BOVALLIUS for *H. gaudichaudi*, M. EDW. (Hyperidea, Plate X., fig. 20). If *H. latreillei*, M. EDW., is to be united to *H. galba*, as proposed by SARS ('Amph. of Norway,' p. 7), there seems to be no reason why *H. gaudichaudi*, which BOVALLIUS (*loc. cit.*, p. 176) considers "a link between" these 2 species, should not also be included. The shape of the gnathopods in the present specimens is nearer to *H. galba* than to *H. gaudichaudi* as figured by BOVALLIUS.

Hyperia bengalensis (GILES).

Lestrigonus bengalensis, GILES, 'Journ. of Asiatic Soc. of Bengal,' 1887, p. 224.

Hyperia dysschistus, STEBBING, '"Chall." Amph.,' p. 1388, Plate 167, 1888.

There can be little doubt of the identity of the above; STEBBING, with his usual acuteness, observed the similarity, but was misled partly by the distance between the two stations (*H. dysschistus* was taken off Cape Howe, Australia) and partly by errors in GILES' description of the telson and uropods. As suggested by BOVALLIUS (*loc. cit.*, p. 200), GILES has mistaken the projecting hind margin of the urosome for the

telson, which is unusually diaphanous and easily overlooked; while he has mistaken the 1st uropods for the 2nd owing to the former crossing the latter, as is common in a mounted specimen. As a matter of fact, the uropods are quite normal. The line of demarcation between the 2nd and 3rd urosome segments is also very difficult to see; it is correctly shown by STEBBING (*loc. cit.*, Plate 167) at the base of what was believed by GILES to be the telson. The posterior angle of the 3rd pleon segment is a sharp right angle as in *H. dysschistus*, and not rounded as drawn by GILES.

There is no doubt that our specimens are *H. dysschistus*, STEB., and, considering the localities and the deceptive nature of the characters in which Dr. GILES has erred, that they are also *H. bengalensis* (GILES).

The gnathopods agree well with the figures of *H. dysschistus* in BOVALLIUS (*loc. cit.*, Plate XI., figs. 1, 2).

This species presents a curious case of male dimorphism. The lower antennæ of the *smallest* males (2·25 millims.) have the very long and slender flagella generally considered characteristic of sexual maturity, while other males, with the antennæ imperfectly developed, measure 3·25 millims. Perhaps, as in the case of *Bathyporeia pilosa*, LIND., mentioned by BONNIER (' Travail du Lab. de Zoologie de Wimereux'), the males become sexually mature before they are full grown, and lose their nuptial appendages after copulation.

Several specimens from various localities at Ceylon.

Hyperia crucipes, BOVALLIUS.

In addition to the distinctive characters given by BOVALLIUS may be mentioned the great relative width of the 4th and the ciliate margin of the 5th joint in the 1st and 2nd peræopods.

Two, young, Station LXVI. Length 2·5 millims.

Hyperoche, BOVALLIUS, 1887.

Hyperoche cryptodactylus, STEBBING, ' "Chall." Amph.,' p. 1399, Plate 170.

One male, length 4 millims., Galle harbour.

The "Challenger" specimen was taken near the Cape of Good Hope.

Phrosina, RISSO, 1822.

Phrosina sp.

One, young—no locality. Length 2·5 millims.

Too young for identification.

Parascelus, CLAUS, 1879.

Parascelus parvus, CLAUS—Plate I., fig. 1.

One, male, length 3·5 millims.

The first (upper) antennæ have the 1st joint of the flagellum very wide and as long as the next two (fig. 1. ant.[1]).

The second antennæ have the last 3 joints subequal.

The gnathopods agree with STEBBING'S description ('"Chall." Amph.,' p. 1501); I could see no trace of the teeth shown on the carpus in CLAUS' figure ('Platysceliden,' p. 47, Plate VII., fig. 15); this is probably, from his description, exaggerated in the drawing.

Elsia, GILES, 1888.*

Elsia indica, GILES—Plate I., figs. 2.

Five or six male, female, and young. Length of male 5 millims., female with ova rather less.

Description of male (now found for the first time):—The head is produced and tumid in front, the eyes occupying the posterior half; it is fully as long as the first 4 segments.

Mesosome rather longer than pleon; the first 2 segments together as long as the 3rd, the 5th and 6th longest. The 1st segment of the pleon is longest, the 3rd shortest, the hinder angle of the latter is bluntly rectangular.

Upper antennæ attached to the extreme edge of the lower part of the front of the head, inflated, with the upper surface depressed and the lower convex. Flagellum minute, apparently 2-jointed (fig. 2. ant.^{1}).

Lower antennæ of the usual form in males of this family, the 1st joint widened distally; the 3rd longer than the 4th and 5th, the latter very short.

No mouth organs or maxillipeds were found.

Gnathopods alike, small; 1st joint narrow, margin straight and parallel, longer than the remaining 5 joints; 2nd and 3rd subequal; hind margin of wrist extending nearly to the end of that of the hand, like a pair of shears with smooth inner margins; hand much shorter and narrower than the wrist, tapering slightly to the dactylus, which is very small (fig. 2. gn.^{1}).

First and 2nd peræopods very slender, 1st joint as long as and scarcely wider than the 3rd and 4th; margins straight, parallel; 4th and 5th subequal; dactylus minute.

Third peræopods very powerful; 1st joint ovate, about as long as and but little wider than the 4th, narrowing distally; front margin obsoletely serrate; 3rd about two-thirds of the 4th, both widening distally; 4th and 5th subequal in length and width, the 4th rather wider at its distal end, both obsoletely serrate on both margins; dactylus very minute (fig. 2. pp.^{3}).

Fourth peræopods like the third, but rather smaller.

Fifth peræopods small; 1st joint oval, widest near the base, and scarcely as long as the remaining joints; 3rd about twice as long as 4th; 5th as long as 3rd and 4th, narrowing distally; dactylus minute (fig. 2. pp.^{5}).

* 'Journ. Asiat. Soc. of Bengal,' 1888, p. 250, Plate VI.

Uropods shortening progressively in extent, so that the 1st project the furthest; the inner ramus of the 1st is about half as large as the outer; the rami of the 2nd and 3rd pairs are subequal in length and breadth, and are all ciliate on the inner margins.

The telson is semi-oval, covering two-thirds of the rami of the 3rd uropods.

The only known species of the genus, and easily recognizable by the powerful 3rd and 4th peræopods.

Hyale, Rathke, 1837.

Hyale nilssoni (Rathke), var.

Station XLVII., 1 male; Station LVIII., 9 specimens.

This is the same form as that taken by Dr. H. O. Forbes on shore on the island of Abd-el-Kuri ('Nat. Hist. of Sokotra and Abd-el-Kuri,' 1903, p. 219). As there stated, it differs from the type in the length of antennæ (in the specimen from Station XLVII. not even in that); in the more rounded lobe of the wrist in the 1st gnathopod of the male and the 1st and 2nd gnathopods of the female; and in the 1st joints of the last 3 pairs of peræopods, which are serrate instead of smooth. I do not consider these differences sufficient to constitute a new species, but, if anyone wishes to do so, I suggest the name "*kuriensis*." They seem to me, however, quite as important as those that characterize some other species, such as *H. stebbingi*, Chevreux, and *H. grimaldii*, Chev. ('Résult. des Camp. Sci. de "l'Hirondelle,"' pp. 8–10), but the genus appears to have been rather overworked.

Ichnopus, A. Costa, 1853.

Ichnopus taurus, Costa.—Plate I., fig. 3.

One male, Station XLI., about 100 fathoms.

The only point in which this species seems to differ from Della Valle's description, &c. ('Gamm. d. Golfo di Napoli,' p. 802, Plate 27), is in the comparative squareness of the 1st joint and the greater width of the 3rd and 4th joints of the 3rd peræopods in our specimen (fig. 3, pp.[3]). I agree with Della Valle that *I. spinicornis*, Boeck, and *I. affinis*, Heller, can hardly be considered distinct species.

Socarnes, Boeck, 1870.

Socarnes schmardæ (Heller).

Anonyx schmardæ, Heller, 'Amph. des Adriatischen Meeres.'
Ichnopus schmardæ, Heller, Della Valle, *loc. cit.*

One male, Station VI.

Lateral angle of the head moderately produced, acute. Eyes occupying almost the whole head. Posterior margin of the 3rd pleon segment slightly convex, lower margin straight, angle rounded. The 1st urus segment is dorsally depressed.

The wrist of the 1st gnathopods is considerably wider at the distal end than the base of the hand; the latter has 2 or 3 spines on the posterior margin just beyond the widest part.

Socarnella, n. gen.

Upper antennæ with the 2nd and 3rd joints well developed, and the 1st joint of the flagellum like the succeeding joints.

Mandibles as in *Amaryllis*.

First maxillæ with a palp.

First gnathopod not subchelate.

Second gnathopod with hand long and widening distally.

Outer ramus of 3rd uropods without a terminal joint.

Telson small, emarginate at the tip.

Socarnella bonnieri,* n. sp.—Plate I., figs. 4.

One female; length 5 millims. Reef, Galle, with compound Ascidians (February 16, 1902). Head with the ocular lobe produced; convex on the upper side. Eyes large, oval, dark, with large crystalline facets.

Third segment of pleon with the hind margin convex, the lower margin straight, posterior angle rounded (fig. 4. pl.[3]); the 2nd segment has the posterior angle acute.

First 4 side plates rather deeper than the segments.

First segment of urus even.

Upper antennæ: 1st joint twice as long as wide, and as long as the 2 succeeding; 2nd rather longer than 3rd, which is subequal to the 1st joint of the flagellum. Flagellum setose, 9-jointed; the 1st joint like the succeeding, but twice as long as the 2nd. Appendage strong, 5-jointed, reaching to the 4th joint of the flagellum. The 1st and 2nd joints of the peduncle are acutely produced below, the 2nd more than the 1st (fig. 4. ant.[1]).

Lower antennæ: 2nd joint widening distally, rather longer than the 3rd, the two together about as long as the 7-jointed flagellum.

Mandible much as in *Amaryllis*, the palp placed near the proximal end, the 3rd joint about one-third of the 2nd, bent at a right angle (fig. 4. m.).

First maxillæ with a strong 2-jointed palp; outer plate with about 7 dentate spines; inner plate half as high as the outer, pointed, with 2 or 3 unequal setæ at the tip (fig. 4. mx.[1]).

Maxillipeds: inner plates reaching beyond the 1st joint of the palp, dentate at the ends, setose on the inner margin; outer plates broad, reaching the middle of the 3rd joint, margins smooth. Dactylus distinctly unguiform, acute (fig. 4. mxp.).

* I have much pleasure in dedicating this species to Mons. JULES BONNIER, who has contributed so much to a better knowledge of the Amphipoda.

First gnathopods: 1st joint with almost parallel margins, as long as the next 4; 2nd as wide, about one-fourth as long as the 1st and longer than 3rd or 4th; the 3rd overlapping the 4th, cordate, the point distal, hind margin very convex; wrist rather shorter than the hand, widening distally; base of the hand as wide as the wrist, narrowing to the dactylus; the latter short, curved, with a secondary tooth near the point. All the joints, except the 1st and 6th, have long setæ on the hind margin. Side plates subrectangular with rounded angles, wider than the next two (fig. 4. gn.[1]).

Second gnathopods: 1st joint about as long as the next 3, curved and widening distally; 2nd almost as long as the 4th, with 2 or 3 long stiff setæ in a depression on the hind margin near the distal end; 3rd very convex, with a group of erect setæ on the hind margin. Length of wrist to hand as 5 : 3, the former narrow, hind margin slightly concave, with short setæ and scanty fur at the distal end: the hand widens gradually to the end, furred on the hind margin, with short setæ on the front and a tuft of long setæ at the base of the dactylus; this is strong and overlaps the hind margin (fig. 4. gn.[2]).

First and 2nd peræopods slender, with few setæ and no spines.

Third peræopods: side plates wider than deep, lobes equal, larger than the 1st joint, which is suborbicular, flattened behind, margins smooth, a few setæ on the lower part of the front.

Fourth peræopods: the 1st joint flattened behind, the lower part of the front margin spinous; the upper part of the hind margin faintly serrate.

Fifth peræopods: the 1st joint rounded and more distinctly serrate behind, spinous on the lower part of the front margin.

First uropods spinous, the rather slender peduncle considerably longer than the subequal rami.

Second uropods: peduncle wide at the base, narrowing distally and about as long as the outer ramus, which is rather longer than the inner and spinous; the inner has one spine near the end (fig. 4. up.[2]).

Third uropods: peduncle longer than the rami, with 2 or 3 spines and a distal tooth on the outer margin; outer ramus rather the longer, *without a terminal joint*, with 2 spines dividing it into 3 equal parts (fig. 4. up.[3]).

Telson about half the length of the peduncle of the 3rd uropods, oval, deeply emarginate at the end, with a short spine on each of the lobes (fig. 4. ur.).

This genus differs from *Amaryllis* in the presence of a palp to the 1st maxillæ and in the smaller side plates of the first 4 segments. From *Socarnes* it differs in the mandibles, maxillipeds, 2nd gnathopods, telson, and 3rd uropods. It may be considered as connecting these two genera. The excavated point of the telson separates it from *Lysianax*, though Della Valle (*loc. cit.*, p. 789, plate 25) has described a species under the name of *L. punctatus* with a similar telson. From this the present species differs in the antennæ, 1st maxillæ, &c.

Vijaya,* n. gen.

Upper antennæ in the male with the 1st joint of the flagellum much longer than any of the succeeding joints and very setose.

Mandibular palp set on in the middle of the trunk.

The remaining characters and the female antennæ as in *Amaryllis*, STEBBING, '"Chall." Rep.,' p. 699.

The curious difference in the male and female antennæ makes a new genus necessary.

Vijaya tenuipes, n. sp.—Plate I., figs. 5.

Coast of Ceylon, shallow water, 2 specimens, length 4 millims.

Head very deep, rostrum small, bent downwards; ocular lobe obtuse-angled. Eyes very large, long-oval.

Third pleon segment with the hind margin slightly convex, lower almost straight; the posterior angle acute, upturned, with a sinus above it, as in the other species of this genus (fig. 5. pl.[3]).

Antennæ in female subequal, reaching the hind margin of the 4th side-plates, which are very large.

Upper antennæ (female): 1st joint about twice as long and wide as the 2nd, produced below in a distal tooth; the 2nd the same proportion to the third; flagellum considerably longer than the peduncle, *the 1st joint resembling and rather shorter than the 2nd, quite naked;* appendage barely reaching the end of the 1st joint of the flagellum; 2-jointed, the 1st twice as long and wide as the 2nd (figs. 5. ant.[1]).

The upper antennæ in the male have the 1st joint of the flagellum as long as the next three and densely setose on the inner side, both flagella are broken, one at the 12th joint; the appendage is 3-jointed, the 1st joint twice as long as the 2nd, which is about in the same proportion to the 3rd: this is extremely narrow and reaches the end of the 2nd joint of the flagellum (fig. 5. ant.[1]).

Lower antennæ: the 1st joint very short, the 2nd half as long again as the 3rd (figs. 5. ant.[2]).

Maxillipeds: inner plates reaching beyond the middle of the palp, the ends cut into 3 teeth, sides setose; outer plates transparent, broad, reaching the end of the 3rd joint, dentate on the distal half, the indentations deeper towards the end. Second joint of the palp rather longer than the 1st or 3rd, which are subequal. Dactylus slender, with the inner margin finely denticulate and 2 or 3 setæ on the point.

First gnathopods: 1st joint as long as the remaining joints, about 5 times as long as wide; margins subparallel, 2nd longer than 3rd, which is irregularly triangular; wrist about two-thirds as long as the hand, with 3 fascicles of setæ on the hind

* VIJÁYA, an ancient king in Ceylon. See this Report, Part I., 'Introduction,' p. 1.

margin. The hand tapers gradually to the base of the dactylus without a palm, the hind margin finely pectinate with 4 spines and as many pairs of unequal setæ. Dactylus about one-fifth the length of the hand, curved. Side-plates small, oval below (fig. 5. gn.[1]).

Second gnathopods long and slender, the joints of almost uniform width throughout; the 1st slightly curved, about 6 times as long as wide; the 2nd twice as long as the 3rd; the wrist about equal to the two last named, margins straight, the hind margin setose; hand about two-thirds as long as the wrist, margins parallel, the hind margin with long setæ directed forwards. Side-plates nearly as long as the 1st joint, about twice as deep as wide, oval below (fig. 5. gn.[2]).

First and 2nd peræopods: 1st joint about as long as the next three: 2nd very short, 3rd, 4th, and 5th subequal; dactylus strong, about half as long as the preceding joint. Side-plate of the 2nd about as wide as one-fourth of the length of the whole body; hind margin excavated above and rounded below; *front margin with the lower angle produced and acute* (fig. 5. pp.[2]).

The remaining peræopods have the 1st joints expanded and serrate behind, the lower margins in the 3rd and 4th rounded, in the 5th almost straight; front margins spinous; 3rd joints spinous before and behind.

The uropods are damaged; the 1st pair extends the furthest, then the 2nd, which have the peculiar character shown by STEBBING in his figure of *A. macrophthalmus* ('"Chall." Rep.,' Plate 29). The rami of the 3rd pair are straight and lanceolate.

The telson reaches to about one-third of the length of the peduncle of the 3rd uropods, and is cleft for about one-third of its length, the cleft dehiscent.

This species may be distinguished by the acute anterior angle of the 4th side-plate, and by the straightness of the wrist and hand of the 2nd gnathopods. It may be identical with *Glycerina affinis*, CHILTON ('Trans. N.Z. Institute,' vol. xxiv., p. 2, Plate XLVII.), but the description of that species is not sufficient to determine the point.

Lysianax, STEBBING, 1888.

Lysianax cinghalensis, STEBBING.*—Plate I., fig. 6.

L. urodus, A. O. WALKER, 'Nat. Hist. of Sokotra,' &c., 1903, p. 220, Plate XIV., fig. 4.

Various localities round the coast of Ceylon.

This appears to be a variable species. Most of the specimens examined have a 4-jointed appendage to the upper antennæ, and, while in one male the 1st gnathopod resembles that of Mr. STEBBING's specimen, in another the hand is conical, with a straight dactylus continuous with the hand. The 1st joint of the 5th peræopods also varies, having the lower margin truncate in some and rounded in other specimens.

* 'Trans. Linn. Soc.,' Ser. 2, vol. 7, p. 28; Plate VII., A, 1896.

The apex of the telson is sometimes truncate. The small setiferous notch in the front margin of the side-plate of the 1st gnathopod, figured by STEBBING, is a constant character; it occurs also in *L. urodus*, which I consider identical with this species.

The mandibular palp has 1 or 2 spines in the middle of the concave side of the 3rd joint, which is rather more than half as long as the 2nd (fig. 6. mp.).

Length of male, 6 millims.; of female, 10 millims.

Lysianax cœlochir,* n. sp.—Plate I., figs. 7.

Stations LIII., LVIII.—about 16 specimens, males and females.

Head rather longer than the 1st segment; ocular lobe produced, subacute.

Epistome prominent.

Hind margin of the 3rd pleon segment rounded.

Anterior angle of 1st pleon segment rounded, posterior acute.

Upper antennæ subequal to the lower; 1st joint more than half as wide as long and rather longer than the next two. First joint of the 8-jointed flagellum subequal to and like the 2nd, shorter than the 3rd; appendage 4-jointed, the 2nd and 3rd the longest (fig. 7. ant.[1])

Mandibles normal, the 2nd joint of the palp nearly 3 times as long as the 3rd, which has no spine on the concave margin. Remaining mouth organs normal.

First gnathopods strong, the hand and dactylus in the same line; side plates large, much widened below with a small notch in the anterior margin near the lower angle, as in *L. cinghalensis* (fig. 7. gn.[1]).

Second gnathopods: 1st joint almost as long as the next 3; 2nd joint subequal to the 4th; 3rd much shorter and almost as wide as the wrist, which has the hind margin very convex and squamous, the front margin straight, with divergent setæ. The hand is about two-thirds the length of the wrist, the front margin rather convex and truncate at the end; the distal portion of the hind margin hollowed out, the whole very setose. Dactylus much curved, the base at the angle formed by the truncate end and the posterior sinus (fig. 7, gn.[2]).

Peræopods as in *L. cinghalensis*.

The 2nd uropods have spines on both the subequal rami and extend beyond the 3rd (fig. 7. ur.).

The 3rd uropods have the peduncles produced to a tooth at the outer angle and considerably longer than the rami, of which the outer is slightly the longer; the whole limb without spines (fig. 7. ur.).

Telson oval, barely reaching half the length of the 3rd uropods, not truncate.

Length 7·5 millims.

This species can hardly be distinguished from *L. cinghalensis*, except by the characteristic and peculiar hand of the 2nd gnathopods.

* From κοῖλος, hollow, χείρ, hand referring to the excavated palm of the 2nd gnathopods.

Orchomenella, SARS, 1894.

Orchomenella nana (KRÖYER) = **O. ciliata**, SARS, 'Amph. of Norway.'

Cheval Paar; February, 1902; 30–40 specimens.

Length of male, 5·5 millims.

Tryphosa, BOECK, 1870.

Tryphosa cucullata,* n. sp.—Plate IV., fig. 8.

Kondatchi Paar; 17th November, 1902; one male. Length 5·5 millims.

Body compressed; first 4 side-plates twice as deep as the segments, the 4th deeply excavated behind; the 5th deeper than wide. The 3rd pleon segment has the hind and lower margins straight, the posterior angle bluntly rectangular; the upper margin produced in a subacute tooth behind. The 1st urus segment has a deep dorsal depression with a subangular carina behind it.

Head nearly as long as the 1st segment, produced in front; ocular lobe acute, produced to the 2nd joint of the upper antennæ. Eyes large, oval, red.

Upper antennæ: 1st joint tumid, projecting over the 2nd, which again completely overhangs and conceals the 3rd. First joint of the flagellum fully as long as the remaining 5, with about 10 rows of setules and a dense brush of long setæ. Appendage 5-jointed, not reaching the end of the 1st joint of the flagellum, the joints subequal (fig. 8).

Lower antennæ of the usual character of the males of this family, the flagellum reaching the urus.

Mouth organs and maxillipeds not examined.

First gnathopods as in *T. angulata*, G. O. SARS, the palm very oblique.

Second gnathopods: wrist much expanded below, without furring or setæ; lower margin of the hand produced; dactylus small.

The last 3 pair of peræopods are subequal and have the 1st joints wide, smooth, and rounded behind, spinous in front; the 3rd joints are much expanded behind, more so than in any of the species of *Tryphosa* figured by SARS.

The 3rd uropods have the rami widely lanceolate, rather longer than the peduncle, and spinous on their inner margins; they extend rather beyond the 2nd and as far as the 1st pair.

Telson convex on the upper side, long, reaching to the middle of the 3rd uropods, divided nearly to the base, with 2 or 3 submarginal spines and a larger apical spine on each division.

The single specimen was not dissected, but it is distinguished by the peculiar hooded character of the peduncular joints of the upper antennæ, in which respect it resembles the genus *Ambasia*, from which, however, it differs in the form of the 1st gnathopod.

* From the hood-like character of the first 2 joints of the upper antennæ.

Urothoë, Dana, 1852.

Urothoë spinidigitus,* n. sp.—Plate I., figs. 9.

Cheval Paar; November, 1902. One male, length 4 millims.

Body rounded, as deep as wide. Pleon segments all rounded behind.

Eyes very large, contiguous above, round, with large facets, red (fig. 9. c.).

Upper antennæ: 1st joint about three-fourths as long and twice as wide as the 2nd.

Lower antennæ: 1st joint very short, 2nd considerably longer than the 3rd; widening distally, setose on the upper and outer margins, and with an irregular row of spines (longer and sharper at the distal end) on the lower outer margin; 3rd joint swollen in the middle, with calceoli on the upper margin, and 7 or 8 long and weak setæ below. Flagellum very long and slender (fig. 9. c.).

Mandibles normal; the last joint of the palp with 6 setæ on the distal half and one or two very long setæ at the tip.

Maxillipeds: inner plates reaching half way up the outer, narrowed distally and crowned with 2 strong spine-teeth and one or two intermediate setules. Outer plates with curved spines and intermediate setæ; they barely reach the end of the 2nd joint of the palp, which is very broad.

First and 2nd gnathopods: side-plates very small, the 1st acutely angled in front, the 2nd rectangular, both without setæ. The limbs are similar in form and armature, the 2nd pair being rather the larger; the 1st joint is pyriform, as long as the hand and wrist; the 2 next short, with very long setæ on the hind margin of the 2nd, as also on the distal portion of the 1st. The wrist is rather longer than the hand in the 1st pair and subequal to it in the second—this joint and the hand are of the usual form, the hand being widest in the middle; the palm of the hand is defined by a peculiar rod-like spine, the end obliquely truncate with a setule at the tip; that of the 1st pair is half as long as the 2nd. The wrist is clothed with long setæ on the projecting portion, and the hand just below the palmar spine on the hind margin. Dactylus slender, with a setule on outer margin near the point (fig. 9. gn.[1]).

Side-plates of the 1st peræopods small, irregularly oblong; 1st joint rather longer than 3rd and 4th, the 3rd longer than the 4th, which has 4 blunt spines on the hind margin; 5th joint shorter and much narrower than the 4th, dilated and rounded at the end, where there are 4 spines of unequal length on the hind margin and 2 very short ones at the base of the dactylus. The dactylus is straight and slender, with 5 denticles on the inner side, the one nearest the point being the largest (fig. 9. pp.[1]).

Third peræopods: the 1st joint has the upper part projecting behind with 7 or 8 marginal setæ; front margin almost straight; 2nd joint very short; 3rd twice as long as 2nd, with a row of blunt spines just above the lower margin and 4 or 5 plumose setæ on the hind margin; 4th greatly expanded, with 2 parallel transverse ridges bordered with strong blunt spines and very long plumose setæ; 5th longer

* From the peculiar character of the dactylus of the 3rd peræopods.

and narrower than the 4th, with 3 irregular rows of similar, but more unequal, spines and setæ. Dactylus wide, with 4 long and 4 short spines in 2 parallel longitudinal rows on the front side (fig. 9. pp.^{3}).

Fourth peræopods: 1st joint oblong, widening distally, and almost as long as the 3rd and 4th; a submarginal row of plumose setæ near the hind margin, which ends in a blunt right angle, and a few spines and simple setæ on the front margin; 2nd joint about half as long as the 3rd, which is about three-fourths of the 4th, and has 7 long plumose setæ on the hind margin; the 4th is nearly twice as long as the 5th, very spinous on the front and with simple setæ on the hind margin; 5th spinous in front and at the end; dactylus almost straight, slender, minutely and irregularly tuberculated with a denticle near the points (fig. 9. pp.^{4}).

Fifth peræopods like the 4th, except the 1st joint, which is more than twice as long as wide, narrowing distally and rounded behind, without setæ or spines on either margin; the 3rd joint has no setæ on the hind margin except a distal tuft (fig. 9. pp.^{5}).

First and 2nd uropods: peduncles with a distal spine at the outer and a seta at the inner angle; rami straight and subequal.

Third uropods as in *U. norwegica*, BOECK, as figured by G. O. SARS ('Amph. of Norway,' Plate 47), except that there are fewer spines on the outer margin of the outer ramus. Telson also as in *U. norwegica*.

A small male and female from the same tube, with well-developed lower antennæ, but only 2·5 millims. long, might, from observation of external characters only, be *U. elegans*, SP. BATE. I have long believed that differences of age would account for some of the species that have been established, and for which I would refer to Mr. STEBBING'S valuable paper on the genus ('Trans. Zool. Soc. of London,' vol. 13, Part 1, 1891). The species described above may be distinguished by the curious spiny dactylus of the 3rd peræopods (Plate I., fig. 9. pp.^{3}).

FAMILY: ARGISSIDÆ, nov.

First or upper antennæ in the males with the flagellum longer and more slender than in the females.

Gnathopods subequal and similar.

Last one or two pairs of peræopods much more powerful than the rest of the limbs.

Argissa, BOECK, 1870.

Argissa hamatipes (NORMAN).

Syrrhoë hamatipes, NORMAN, 'Brit. Assoc. Shetland Dredging Rep.,' 1868.
Argissa typica, BOECK, 'Crust. Amph. bor. and arct.,' 1870, p. 45.
Chimæropsis danica, MEINERT.
Argissa typica, G. O. SARS, 'Amphipoda of Norway,' p. 141, Plate 48.
Argissa hamatipes, NORMAN, 'Ann. and Mag. Nat. Hist.,' 7, vol. 10, p. 480, 1902.

Kondatchi Paar; 17th November, 1902; one female with ova.

Length 2·5 millims.

Platyischnopus, Stebbing, 1888.

Platyischnopus herdmani, *n. sp.*—Plate II., figs. 10.

Periya Paar Kerrai and E. Cheval Paar, November, 1902.

About 21 specimens. Colour in spirit, light brown.

Body compressed. Head nearly as long as the first 4 segments, produced to a point which is wrinkled or puckered, as in *P. mirabilis*, Stebbing, and surrounded with short spines (fig. 10. c. ♂). No eyes discernible.

The first 3 segments are subequal and shorter than the other mesosome segments, which increase in length successively.

The 3rd pleon segment has 2 dorsal and 1 or 2 dorso-lateral teeth just below the dorsal on each side on the hind margin, the posterior angle upturned, acute; the lower margin convex (fig. 10. $pl.^3$).

Upper antennæ placed considerably in front of the lower: in the female they are short, the 3rd joint of the flagellum reaching the end of the head; two joints only of the peduncle are visible, the 1st shorter than the 2nd; the flagellum 6-jointed; appendage barely reaching the end of the 2nd joint of the flagellum, 2-jointed, the 1st longer than the 2nd; the whole antenna without spines or setæ, except single ones at the ends of joints (fig. 10. $ant.^1$ ♀).

In the male the upper antennæ are entirely different: the 1st joint of the peduncle is swollen and hemispherical, the 2nd twice as long as the 3rd, which has a dense fringe round the distal end: the flagellum is longer than the whole animal and very slender, the 1st joint as long as the next 3; appendage 2-jointed, about one-fourth the length of the 1st joint of the flagellum, which is more than twice as long as the 2nd (fig. 10. c. ♂).

Lower antennæ (female): the 2nd joint four times as long as, and but little narrower than the 1st, and one-third longer than the 3rd, with 4 nearly equi-distant spines on the front margin and 2 setæ at the end of the hind; otherwise the whole antennæ is naked; the flagellum is 9-jointed, as long as the last 2 joints of the peduncle (fig. 10. $ant.^2$ ♀).

Mandibles as in *P. mirabilis* (fig. 10. m.).

Maxillipeds with the inner plate very small, and tapering, with a short spine and strong plumose setæ on the top; inner edge almost smooth. Palp with the 3rd joint shorter than the 2nd, widening distally.

First gnathopods: side-plates small and narrowly oval; 1st joint as long as the next two, much distended distally; wrist almost as long as the 1st joint, narrow; hand about half as long as the wrist, sub-triangular, the hind margin produced to form a chela as in *P. mirabilis* (fig. 10. $gn.^1$).

Second gnathopods like the first, but the wrist nearly twice as long (fig. 10. $gn.^2$).

First peræopods: side-plates rhomboidal, widening below. First joint as long as the next 3; the 3rd longer than the 5th, which is longer and narrower than the 4th; the 4th has a long and a short spine, and the 5th a group of strong spines on the postero-distal margin. Dactylus slender, slightly curved.

Second peræopods with the side-plates much produced behind, otherwise like the 1st (fig. 10. pp.^{2}).

Third peræopods: 1st joint narrow-oblong, widening distally, about as long and wide as the 4th, naked except a long spine on the produced end of the front margin, the remaining joints spinous, the 5th about half as wide as the 4th. Dactylus slender, straight (fig. 10. pp.^{3}).

Fourth and 5th peræopods: 1st joints broadly oval, with two teeth on the lower part of the hind margin; 2nd very small; 3rd much expanded behind, almost as wide as the 1st and considerably wider than the 4th; remaining joints as in the 3rd peræopods. The three last pairs of peræopods increase in length successively, the last two pairs being much the strongest, the 3rd hardly reaching below the 1st joints of the 5th (fig. 10. pp.^{5}).

The 1st and 2nd uropods are slender, the peduncles shorter than the equal rami, all spinous; the 1st are much longer than the 2nd. Third uropods: peduncle strong, cylindrical, with 2 or 3 teeth on the distal margin; outer ramus lamellar, spear-shaped; inner apparently wanting in all the specimens (fig. 10. up.^{3}).

Telson convex above, broad, cleft less than half its length; a tooth on the outer side, 2 upright spines near the middle and a group by the tooth of each division (fig. 10. t.).

This curious genus was first described by Stebbing in the '"Challenger" Report,' from two imperfect specimens of which only one, a female, had a head, so that he was not aware of the remarkable development of the *upper* antennæ in the male. He therefore placed the genus provisionally in the Pontoporeiidæ. I have thought it advisable to form a new family for it and the genus *Argissa*, which also has been placed by Sars, with hesitation, in the same family and, like *Platyischnopus*, is characterised by a similar development of the last peræopods and of the upper antennæ of the male. The present species has much the same general appearance as *P. mirabilis*, Steb., but differs in the sculpture of the last pleon segment, the absence of eyes, the proportions and armature of the antennæ, form of telson, &c. Subsequently ('Ann. and Mag. Nat. Hist.,' Ser. 6, vol. xix., 1897, p. 1, plate v.) Dr. C. Chilton described another species (*P. neozelanicus*) from Otago, also from an imperfect female specimen, which differs in the gnathopods, and many other points from the other two species. It is to be hoped that specimens of the present species will be taken with perfect 3rd uropods; from the appearance of the peduncle I should expect the inner ramus to be long and easily detached as in the case of some of the Gammaridæ.

Leptophoxus, G. O. Sars, 1895.

Leptophoxus uncirostratus (Giles).

Phoxus uncirostratus, Giles, 'J. Asiat. Soc. Bengal,' vol. 59, Pt. II., 1890, p. 65, pl. ii., fig. 2.

Station XXXVII., one old female; length, 10 millims. Station LVIII., one young female.

Ampelisca, Kröyer, 1842.

It will be useful to give here a synopsis of the following species of the genus:—

Upper antennæ extending beyond the peduncle of the lower by *more* than 3 joints of the flagellum.—*A. tridens*, n. sp.

Upper antennæ extending beyond the peduncle of the lower by *less* than 3 joints of the flagellum.

Lower antennæ reaching beyond the pleon.—*A. scabripes*, n. sp.

,, ,, not reaching beyond the pleon.—*A. brachyceras*, n. sp.

Upper antennæ not reaching the end of the peduncle of the lower.

Third uropods ovate; inner margin of outer ramus distinctly serrate.

Posterior angle of 3rd pleon segment acute, much produced, and upturned; head angular below.—*A. brevicornis*, Costa.

Posterior angle of 3rd pleon segment scarcely produced or upturned; head rounded, narrow; one large red eye on each side of the head.—*A. cyclops*, n. sp.

Third uropods lanceolate, outer ramus not serrate.—*A. chevreuxi*, n. sp.

Ampelisca tridens,* n. sp.—Plate II., figs. 11, and Plate IV., figs. 11.

Generally distributed round the coast of Ceylon.

Head rather longer than the first 2 segments, not much produced, with a distinct but rounded lateral angle, just below which the lower and larger eye is placed; the other is close to the base of the upper antennæ (Plate II., fig. 11. c.).

Third pleon segment with the hind margin slightly convex; the posterior angle acute, scarcely upturned; the 2nd pleon segment has the hind margin more convex and the angle less produced.

First urosome segment with a deep dorsal depression, on which are 3 carinæ, each ending in a knob-like prominence. The 2nd segment is also dorsally depressed, with the sides elevated distally, forming a rounded prominence on each side of the base of the telson. The 3rd segment is hidden by the 2nd (Plate IV., fig. 11. ur.).

Upper antennæ reaching to about half the length of the flagellum of the lower, the peduncle to a little beyond the middle of the 2nd joint of its peduncle.

* From the three prominences on the 1st urosome segment.

Lower antennæ about as long as the body.

First and 2nd gnathopods normal; hind margins very setose. Side-plates wider below, with a strong curved tooth at the posterior angle.

First and 2nd peræopods: dactylus nearly twice as long as the 2 preceding joints. Side-plates of the 2nd with the upper posterior angle hollowed, leaving an acute angle below (fig. 11. $pp.^2$).

Third peræopods: 1st joint convex in front, with a rounded expansion behind; a submarginal row of 5 short spines on the 4th joint; 5th joint widening distally, with 3 short submarginal spines on the proximal half.

Fourth peræopods: 1st joint subquadrate.

Fifth peræopods: lower margin of the 1st joint slightly concave, reaching to the end of the 2nd joint, with many long setæ; 2nd joint subquadrate; 3rd joint shorter than 4th, front angle produced with 2 or 3 spines, hind angle slightly produced; 4th joint rather shorter than 2nd, front angle much produced, hind angle not at all; 5th joint oval, widest near the base, about one-fourth longer than the 2nd, a few short spines at the distal end. Dactylus as long as the 5th joint, tapering gradually to a long crooked point (fig. 11. $pp.^5$).

First uropods reaching the end of the peduncle of the 2nd; rami slender, curved, unarmed, about as long as the peduncle. Second reaching beyond the end of the peduncle of the 3rd, rami wider than those of the 1st pair, straight, subequal; a few short spines on their inner margins, the outer with a long serrate spine near the end of the inner margin.

Third uropods: the peduncle narrowed abruptly in the middle, where there is a curved spine and a setule; outer ramus narrower and a little shorter than the inner, with a long simple spine near the tip and a few plumose setæ on the distal half of the inner margin; inner ramus with the end slightly curved outwards, 3 slender spines near the end of the inner margin and 2 unequal setæ on the rounded point; both rami are widest at about one-fourth their length from the peduncle (fig. 11. ur.).

Telson divided to the base, without spines; a few setules on a median fold of each division; this is sometimes notched at the end with a setule in the notch (fig. 11. t.).

Length, 10 millims.

Distinguishable by the prominences on the urosome segments.

Ampelisca scabripes,* n. sp.—Plate II., figs. 12.

Areas (A), (C), (H): apparently not abundant.

Head as long as the first 2 segments, rounded below the upper antennæ. Eyes distant, with a crimson spot behind each, and a smaller one behind the uppermost (fig. 12. c.).

Hind margin of the 3rd pleon segment convex, the angle upturned but rounded (fig. 12. $pl.^3$).

* From the scabrous 4th joint of the 3rd and 4th peræopods.

First urosome segment with a dorsal depression, not carinate.

Upper antennæ reaching a little beyond the peduncle of the lower; the latter longer than the body.

First gnathopods strong; side-plates rounded before, straight behind. First joint widening distally; wrist and hand subequal, about twice as long as wide, setose.

Second gnathopods: 1st joint twice as wide at the distal end as any of the remaining joints; wrist half as long again as the hand.

First and 2nd peræopods: dactylus hardly as long as the two preceding joints (fig. 12. pp.[1]).

Third and 4th peræopods very short and much alike, except that the upper margin of the membranous posterior lobe of the 1st joint originates from the top of the hind margin in the 3rd, and from lower down in the 4th pair. The 4th joint is broad and produced behind in a truncate lobe, which is scabrous with minute spines, and terminates in a group of unequal spines, of which the longest reaches the end of the 5th joint and is denticulate (fig. 12. pp.[4]).

Fifth peræopods: hind margin of the 1st joint extending downwards to the end of the 2nd, a few short setæ on the lower part of the posterior curve and a long plumose one on the upward recurvature; 2nd joint the longest and the 3rd the shortest of the remaining joints, neither produced at the angles; 4th and 5th subequal in length and width, the latter ovate; last joint ovate, with a minute point and setule at the end (fig. 12. pp.[5]).

First uropods reaching the end of the 2nd pair; rami curved, rather shorter than the peduncle.

Second uropods with straight rami considerably shorter than the peduncle, inner ramus finely serrate on the outer, outer ramus on the inner margin.

Third uropods: rami* nearly twice as long as the peduncle, lanceolate, the inner the wider dentate along the distal half of its inner margin, the teeth increasing in size distally, and 3 or 4 setæ near the end of the outer; outer ramus minutely spinous near the end of the outer margin, with 3 or 4 fine submarginal and a pair of terminal setæ (fig. 12. ur.).

Telson divided to the base and covering a fourth of the length of the rami of the 3rd uropods; a notch and spine at the end of each division, a marginal spine just behind the end, and a seta behind the spine.

Characterized by the spinous 4th joints of the 3rd and 4th peræopods, the form and proportions of the joints of the 5th and the serrate and dentate 3rd uropods.

Length, 6 millims.

A. brachyceras,† n. sp.—Plate II., figs. 13.

Kondatchi Paar, 1; Cheval Paar, 1; both November, 1902.

* In the specimen figured the rami are double—probably the result of an imperfect moult.

† In allusion to the shortness of the antennæ.

Head of an unusual form in this genus, the lower antennæ originating immediately below the upper with a well-defined but rounded lateral angle. Eyes scarcely discernible (fig. 13. c.).

Third pleon segment with the hind margin slightly convex, the lower margin straight till turned up to meet the slightly produced angle (fig. 13. pl.[3]).

First segment of the urus with a small carina.

Antennæ short, the lower rather the longer, reaching the end of the 2nd mesosome segment. First joint of the upper about twice as long and as thick again as the 2nd; 3rd not distinguishable from the flagellum, which is 5-jointed without the above doubtful joint, with a long terminal seta. The lower have the first 2 joints subequal, the 3rd the longest, with 5 spines on the lower margin.

Gnathopods normal.

First and 2nd peræopods of the usual form, the dactylus about as long as the 2 preceding joints.

Third and 4th peræopods: 1st joint fully as wide as long; 4th joint has the posterior longitudinal half produced downwards for two-thirds of the length of the 5th joint, terminating in 2 long, unequal serrate spines. In the 4th pair the dactylus is rudimentary (fig. 13. pp.[4]).

Fifth peræopods: 1st joint with the front margin longer than the remaining joints; it is concave on the upper and convex on the lower part; the hind margin evenly convex, reaching downwards to the 5th joint; about 9 simple unequal setæ and 4 or 5 setules on the lower part; 2nd joint longer than any of the succeeding, 4th, 5th, and 6th subequal, the last lanceolate, acute. None of the joints have their angles materially produced (fig. 13. pp.[5]).

First uropods: peduncles almost twice as long as the subequal rami; 2 spinous and finely pectinate ridges on their upper sides; rami curved, unarmed, except a spine near the base of the inner.

Second uropods: peduncles rather longer than the subequal rami, sparsely spinous; rami straight, 5 spines on the inner margin of the inner (fig. 13. ur.).

Third uropods: rami rather longer than the peduncles, the outer having the outer margin very convex, the distal half beautifully ornamented with a double row of minute spines; the inner margins straight with a few long setæ; inner rami concealed by the outer—apparently as long and wide as these—with long and dense setæ at the tips (fig. 13. ur.).

Telson divided about three-fourths of its length, with long upright setæ along the margins of the cleft.

Length 4·5 millims.

Easily recognisable by the short antennæ, the peculiar structure of the 4th joints of the 3rd and 4th and the 1st joint of the 5th peræopods, and the curiously formed and ornamented 3rd uropods.

Ampelisca brevicornis (Costa, 1853).

A. lævigata, Lilljeborg, 1855.

For the synonomy of this species, see Norman in 'Ann. and Mag. Nat. Hist.,' Ser. 7, vol. V. (1900). p. 342.

Stations XXXIV., XXXV., and pearl oyster washings, Muttuvaratu Paar.

Length 5 7 millims.

Ampelisca cyclops,* n. sp. - Plate II., figs. 14.

Galle, 14th February, 1902; Kondatchi Paar, 17th November, 1902.

Head as long as the first 3 segments, produced to the end of the 1st joint of the upper antennæ, where it is almost cylindrical. At the extreme end are 2 large confluent crimson spots in which are placed 1 or 2 (I could only see one, apparently between the 2 red spots) crystalline lens (fig. 14. c.).

The 2nd and 3rd segments of the pleon have a low dorsal carina, and the 1st urus segment a higher one, ending abruptly. The hind margin of the 3rd pleon segment is convex and hollowed out just above the acute posterior angle.

The upper antennæ are placed much in front of the lower and reach nearly to the end of the peduncle of these; the 1st joint twice as thick and more than half as long as the 2nd; the 3rd rather shorter than the 1st joint of the flagellum, which is 5-jointed and scarcely as long as the peduncle; this, in the adult, has 9 or 10 long plumose setæ on the lower side.

The lower antennæ reach to the pleon; the 1st joint does not reach the end of the 1st joint of the upper, though nearly twice as long; the 2nd joint is nearly twice as long as the 1st, the 3rd a little shorter than the 2nd.

Palp of the mandibles long and slender, the 1st joint about half as long as the 3rd, the two together about equal to the 2nd. *This is not dilated, the 3 joints being subequal in width* (fig. 14. m.).

Maxillæ normal, a single setule near the top of the inner lobe of the 1st.

Maxillipeds with the outer plate reaching the top of the 3rd joint of the palp and furnished with 6 disproportionately large oval spine-teeth.

First and 2nd gnathopods normal; the side-plates widened below and fringed with plumose setæ.

First and 2nd peræopods: 5th joint 3 times as long as the 4th, dactylus longer than the two united; side-plates of the 2nd with the upper posterior angle cut away and slightly hollowed; front and hind margin parallel.

Third peræopods: 1st joint wide, posterior lobe rather small, projecting; a long spine on the distal end of the front margin of the 4th joint.

Fourth peræopods: 1st joint subquadrate, 4th and 5th joints very spinous on the front margin. Dactylus like a bird's head (fig. 14. pp.4).

* From the apparently single eye.

Fifth peræopods: posterior lobe of the 1st joint reaching to the end of the 2nd, the anterior half of the lower margin fringed with long plumose setæ; 2nd and 3rd joints short, their angles hardly produced; anterior angle of the 4th joint produced one-third of the length of the 5th, spinous on the truncate end; 5th joint wide oval, truncate at the end; 6th as long as the 5th, tapering gradually to a long curved, very sharp point (fig. 14. pp.[5]).

First uropods reaching to the middle of the rami of the 2nd; rami smooth, curved, subequal, considerably longer than the peduncle; 2nd pair longer than the 1st, peduncle longer than rami, which are subequal, straight and spinous, the spines slender and, at the distal end of both, very long (fig. 14. up.[2]).

Third uropods: peduncle shorter than the rami in the proportion of 3 : 5, unarmed except 3 slender spines on the inner side; outer ramus a little longer than the inner, outer margin, with 4 small spines and plumose setæ, prolonged to a point beyond the inner, which is furnished with long plumose marginal setæ on the distal half; this ramus is narrow near the base and widest near the middle; the inner ramus is widest about one-third of the distance from its base and is naked except 2 or 3 slender spines near the rounded point and 3 slender spines and 2 plumose setæ on the tip (up.[3]).

The telson is convex on the upper side, cleft rather more than half its length, the sides of the cleft contiguous almost the whole length; margins of the divisions parallel, the ends rounded with a terminal notch and 2 slender spines (fig. 14. t.).

The peculiar shape of the head and appearance of the eye distinguishes this species at once. In the form of the mandibular palp it differs from G. O. Sars' definition, but as one or two of Mr. Stebbing's "Challenger" species differ in the same way, it would seem advisable to disregard that part of the definition.

Ampelisca chevreuxi,* n. sp.—Plate III., figs. 15.

Station LIII. One specimen. Length, 7 millims.

Head narrow and rounded in front, longer than the first 2 segments. Eyes large and prominent, one at the extreme end of the head, the other below the base of the upper antennæ.

Third pleon segment: the hind and lower margins rather convex, the posterior angle a little produced, obtuse (fig. 15. pl.[3]).

Urus with a shallow carina on the 1st segment.

Upper antennæ reaching to about one-third of the last joint of the peduncle of the lower; 1st joint more than half as long as 2nd, 3rd shorter than the 1st joint of the flagellum, which is about 8-jointed.

Lower antennæ scarcely half the length of the body, the 3rd joint rather longer than the 2nd.

Gnathopods and 1st and 2nd peræopods of the usual form; dactylus of the latter rather longer than the 2 preceding joints.

* Named after that distinguished Amphipodist, Monsieur E. Chevreux.

Third peræopods: 1st joint wide, as long as the next 3, the posterior lobe projecting one-third of the length of the hind margin below the top of it; front margin with plumose setæ on the upper part and irregular spines on the lower; 4th joint considerably longer than the 5th, the hind margin produced in a spinous lobe (fig. 15. pp.[3]).

Fourth peræopods: 1st joint as wide as long, the front margin subangular, the part below the angle irregularly spinous; posterior lobe large, the margin evenly rounded and smooth; 2nd joint short, with an angular prominence behind and 2 or 3 short spines in front; 3rd joint longer than the 2nd, with 3 spines on the front margin; 4th joint twice as long as the 3rd, unevenly spinous on the front margin, which ends with 1 long and 2 short spines; the hind margin is naked, but ends in a cluster of unequal spines (one very long) on a truncate lobe; the 5th joint has 12 spines, increasing in length distally and a long terminal one on the front margin, and 3 short ciliate spines on the hind (fig. 15. pp.[4]).

Fifth peræopods: 1st joint produced behind to the end of the 2nd joint, with long plumose setæ on the lower margin; 2nd joint as long as the 2 next and much wider at the top than any of the succeeding joints—*the distal third of the front margin cut away;* 3rd joint about half as long as the 4th, somewhat produced in front; 4th as wide and more than half as long as the 5th, the front angle rounded off and spinous, hind angle slightly produced and spinous; 5th joint oval; 6th narrowed rather suddenly to a long crooked point (fig. 15. pp.[5]).

First uropods: rami curved, subequal, rather longer than the peduncle, inner margins of peduncle and inner ramus spinous.

Second uropods: rami straight, shorter than the peduncle, and spinous on their inner margins, the peduncle stout, with a strong spine at the end of the inner margin.

Third uropods: rami narrow, lanceolate, longer than the peduncle, subequal; the outer the narrower, with a few very small spines on the outer and plumose setæ on the inner margin: the inner has a few setæ on the outer margin near the end (fig. 15. ur.).

Telson divided almost to the base, the divisions pointed, with 3 spines before the point on the outer margin (fig. 15. ur.).

This species may be known by the form of the 2nd joint of the 5th peræopods, &c.

Amphilochus, Sp. Bate, 1862.

Amphilochus neapolitanus (?), Della Valle.

Muttuvaratu pearl oyster washings; 19th November, 1902.

One young and imperfect specimen, length 1·5 millims.

For the synonomy of this species see 'Jour. Linn. Soc.,' vol. 28 (Zool.), p. 300.

Gallea,* n. gen.

Body tumid, integuments strong; 3rd and 4th side-plates very large. Head with a deflexed rostrum. Antennæ subequal; the upper without an appendage and having the 2nd joint produced in a hood-like process over the 3rd. Mandibles with the molar tubercle obsolete; the palp long and slender, the 3 joints subequal.

Gnathopods stout, dissimilar, the 1st pair complexly subchelate as in *Leucothoë;* the 2nd pair rather less powerful, subchelate, as in *Amphilochoides.* Peræopods slender.

Second pair of uropods longer than the 3rd.

A carina runs along each side of the pleon and urus, uniting to form a pointed roof-like projection above the telson. Telson entire.

This is an aberrant genus resembling *Leucothoë* in its first and *Amphilochoides* in its second gnathopods. The length of the 2nd uropods is also unusual in this family, in which they are generally shorter than the 3rd; and the absence of a molar tubercle in the mandibles is inconsistent with G. O. Sars' definition of the family. It is a link between Amphilochidæ and Leucothoidæ.

Gallea tecticauda,† n. sp.—Plate III., figs. 16, and Plate VIII., fig. 16.

An abundant species in several localities round Ceylon.

Head with a small pointed and deflexed rostrum; no ocular lobe. Eye large, round, red, with many facets.

First and 2nd side-plates very small and hidden by the very large 3rd plate, which, with the still larger 4th plate, forms a complete cuirass (Plate VIII., fig. 16).

The 4th and 5th segments are subequal, and each of them as long as the 6th and 7th together; the latter have their lower part produced behind in an acute point; the 2nd pleon segment has the hind angle acute, and the 3rd is considerably produced behind, the convex hind and lower margins together forming a semi-oval.

Urus as long as the last 2 pleon segments, not counting the hood-like process; the 1st segment dorsally depressed, the 2nd produced in a roof-like process convex above and extending over half the telson (Plate III., fig. 16. ur.).

Upper antennæ: 1st joint shorter and wider than the 2nd, its upper and lower margins produced distally: 2nd with an elevated ridge produced above the short 3rd joint for half its length; flagellum 8 or 9-jointed, with 1 or 2 jointed (?) setæ at the end of each joint.

Lower antennæ: 1st joint contracted beyond the middle, the lower margin produced in a short tooth, about two-thirds the length of the 2nd; 3rd rather longer than the 2nd; flagellum 3-jointed, about as long as the 1st joint.

* From the port of Galle.

† From the roof-like projection over the telson.

Mandibles much hollowed below with a roughened portion, which probably represents the molar tubercle and spine row, in the concave part near the cutting edge; this is double in one mandible (in which the spine row also is more conspicuous), is expanded, and has 9 strong teeth (fig. 16. m.).

The palp is as long as the mandible, slender and tapering from the base to a point with a single seta, the joints subequal, the 2nd rather the longest.

First maxillæ: palp 2-jointed, the 2nd the longer; the outer plate is rather wide and crowned with simple spine-teeth; inner plate small, quadrate, with rounded corners and a few fine setules on the top (fig. 16. mx.^{1}).

Second maxillæ normal.

Maxillipeds: inner plate hardly reaching beyond the base of the 1st joint of the palp, with 2 spine teeth a little below the upper margin; outer plate reaching half-way up the 1st joint, with a strong in-curved spine at the outer angle. First and 3rd joints of the palp subequal and longer than the 2nd; dactylus rather long and slender (fig. 16. mxp.).

First gnathopods: 1st joint about as long as the 4th and 5th; 2nd produced behind in a setose spur about half as long as the hind margin of the 3rd; the 3rd longer than the 2nd, produced at both angles; wrist with the hinder part produced in a pointed spur to the end of the hand as in *Leucothoë*, with a few stiff setæ on the inner margin. Hand oblong, with the palm at right angles to the hind margin, the angle rounded; hind margin finely serrate on the distal half, with an intra-marginal row of equidistant spinules; dactylus rather longer than the palm (fig. 16. gn.^{1}).

Second gnathopods less powerful than the 1st; the 1st joint rather longer than the hand with a carina on the distal half of the front margin; wrist rather less than half as long as the hand, the hind margin prolonged in a setose spur along the hand for about one-third of its hind margin, and ending in a cluster of long spines; front margin of the hand straight, hind margin evenly curved, without a definite palm, the edge very minutely pectinate and with an intra-marginal row of spinules. Dactylus curved and slender, not reaching the end of the carpal spur, finely pectinate on the inner margin of the proximal half (fig. 16. gn.^{2}).

First and 2nd peræopods: side-plates rounded below and obtusely angulated above, the 2nd larger than the 1st; limbs slender and naked, except a few spinules on the front margin of the 5th joint; 1st joint narrow (fig. 16. pp.$^{1 \& 2}$).

The remaining peræopods are like the first 2 pairs, but the side-plates are small and much wider than deep, those of the last pair produced behind to an acute angle.

First uropods: peduncle nearly twice as long as the smooth, styliform, equal rami.

Second uropods: peduncle longer than the rami, which are rather unequal, minutely pectinate, and spinulose on the inner margins.

Third uropods: peduncle shorter than the inner and about as long as the outer ramus; rami styliform, the margins minutely pectinate.

The 1st uropods extend beyond the 2nd, and these beyond the 3rd.

Telson entire, oblong-oval, concave above, reaching to the end of the peduncle of the 3rd uropods (fig. 16. ur.).

Length 4 millims.

Leucothoë, Leach, 1813.

Leucothoë spinicarpa (Abildgaard).

Generally distributed.

I can find no differences in the specimens examined to justify referring them to any later species. In a male, 7 millims. long, from Cheval Paar the distal half of the palm of the second gnathopod was more deeply toothed than in Sars' figure, while in smaller specimens from the same tube it agreed. The hind angle of the 3rd pleon segment varies from a blunt right angle to an acute angle in different specimens.

Leucothoë hornelli,* n. sp.—Plate III., figs. 17.

Various localities: in the branchial sacs of Tunicates, &c.

Head as long as the 1st body segment; ocular lobe square, with the upper and lower angles rounded.

Eyes large, dark, pyriform, with the small end lowest.

Segments of the mesosome subequal; first 4 side-plates scarcely deeper than the segments.

First and 3rd pleon segments respectively longer than the 2nd; posterior angle of the 2nd acute; the 3rd has the hind margin of the epimere at first straight, then abruptly incurved, forming a sinus above the acute and slightly upturned angle (fig. 17. $pl.^3$).

Antennæ, mouth organs, maxillipeds, and 1st gnathopods as in *L. spinicarpa.*

Second gnathopods: hand more than twice as long as wide; front margin almost straight or very slightly convex; hind margin with a deep sinus about one-third of its length from the base of the dactylus, followed by 2 smaller sinus, the 3rd being close to the base of the dactylus. In other respects the limb resembles *L. spinicarpa* (fig. 17. $gn.^2$). Peræopods as in *L. spinicarpa.*

Third uropods with the inner ramus almost as long as the peduncle, outer about one-fourth shorter (fig. 17. $up.^3$).

Telson reaching beyond the end of the peduncle of the 3rd uropods, tapering gradually to a very diaphanous blunt point, with 2 small spines on it (fig. 17. $up.^3$).

Length, 5 millims. to 6 millims.

This species resembles *L. spinicarpa* very closely, except in the sculpture of the hand of the 2nd gnathopods and the posterior angle of the 3rd pleon segment, which is nearer *L. lilljeborgii*, Boeck. In young specimens, 2 millims. long, "from *Rhabdocynthia*, Station XIX.," the characteristic indentation of the 2nd gnathopod is plainly

* Named after Mr. Jas. Hornell, F.L.S., now Marine Biologist to the Ceylon Government, by whom, when assisting Professor Herdman, many of the species of Amphipoda described in this work were taken.

to be seen. From *L. furina*, SAVIGNY, it differs in the convex front margin of the hand of the 2nd gnathopod; in the 3rd uropods reaching beyond the 1st and 2nd; and in the quite different shape of the telson.

Leucothoë stegoceras,* n. sp.—Plate III., figs. 17A.

Three specimens from the branchial sac of an Ascidian (*Polycarpa*) from Singapore, sent by Dr. HANITSCH to Professor HERDMAN in 1898.

Head a little longer than the first segment, *produced in front to a hood-like projection over the base of the upper antennæ.* Ocular lobe rounded. Eyes round, colourless in spirit, probably red (fig. 17A, c.).

First 5 segments of the mesosome subequal, the remaining 2 longer.

Posterior angle of the 3rd pleon segment subrectangular.

Upper antennæ a little longer than the lower; the proximal third part of the 1st joint overlapped by the hood of the head; flagellum a little longer than the 2nd joint, 8–9-jointed.

Lower antennæ: flagellum about half as long as the 3rd joint, 6-jointed.

First gnathopods: side-plates securiform, the angles rounded. The rest of the limb as in *L. spinicarpa*, except the 1st joint, which is stronger.

Second gnathopods: side-plates subquadrate, angles rounded. First joint strong, two-thirds of the length of the hand. Carpal process about one-third of the hind margin of the hand, setose. Hand widest opposite the end of the carpal process, where the palm is obscurely defined by a small obtuse tooth; this is succeeded distally by a slightly concave space; then 2 deep sinus and a smaller one followed by a nodular tubercle near the base of the dactylus: this does not quite reach the palmar tooth (fig. 17A. gn.^{2}).

The rest of the animal resembles *L. spinicarpa* so closely that further description is unnecessary. Length, 6 millims.

Easily distinguished by the form of the head.

Anamixis, STEBBING, 1896.†

Anamixis stebbingi, n. sp.—Plate III., figs. 18.

Muttuvaratu pearl oyster washings, 19th November, 1902. One imperfect specimen. Head produced in the middle. Ocular lobe rather deep, the lower angle produced and upturned. Eye round, colourless in spirit.

First body segment apparently coalesced with the head. Posterior angle of the 3rd pleon segment a rounded right angle.

First side-plates rudimentary and concealed by the 2nd, which are much deeper than the segments, pyriform, widest below the middle with a small tooth on each

* Στεγος = roof; κερας = horn; from the roof-like projection over the base of the antennæ.

† 'Trans. Linn. Soc.,' vol. 7, p. 35, Plate 11.

margin ; 3rd similar in form, but narrower and without the teeth ; 4th rather smaller, with a shallow emargination on the lower margin ; remaining side-plates comparatively small.

Upper antennæ rising from the point of the hood-like projection of the head, the peduncle reaching to the end of the 2nd joint of the lower antennæ ; the 1st joint much wider and rather longer than the 2nd, which is subequal to, but thicker than, the 3rd. Flagellum 6-jointed, about as long as the last 2 joints of the peduncle.

Lower antennæ apparently originating behind the articulation of the 2nd gnathopods to their side-plates ; the 3 peduncular joints subequal. Flagellum 3-jointed, half as long as the last joint of the peduncle.

Mouth organs obsolete, except a pair of minute processes called by STEBBING "oral laminæ" in the form of 2 small plates below the head, which are probably rudimentary mandibles.

Maxillipeds : no inner or outer plates ; palp apparently 5-jointed, including the dactylus, the joints subequal, but the 3rd rather the shortest and widest with a long spine on an angular projection on the inner margin ; the 4th rather the longest and narrowest ; the dactylus is slender, curved, and as long as the 4th joint.

First gnathopods very small and perfectly chelate ; the 1st joint as long as all the rest, narrow at the top and widening suddenly a little below the middle ; 2nd joint rather shorter than the 3rd ; this takes the place of the wrist, which is obsolete, and supports the hand ; this has the hinder part produced in an immovable finger as long as the rest of the hand, the end curved upwards and rounded at the point. The dactylus is a little shorter than the immovable finger and curved downwards, the ends of the fingers crossing ; to complete the resemblance to the chelipede of a crab, the inner margin is furnished with blunt teeth. The entire limb extended is slightly longer than the hand of the 2nd gnathopods (fig. 18. $gn.^1$).

Second gnathopods : the 1st joint conspicuously articulated to the middle of the side-plate, as long as the hand, curved and widening distally ; 2nd joint with a wide groove to receive the base of the wrist ; 3rd joint oval, pointed, and articulating with the wrist at about one-fourth of its length from the base ; wrist produced in a curved and pointed process almost as long as the hind margin of the hand, denticulate on the inner margin near the base. Hand widest near the base, front margin convex, hind rather concave beyond the middle. Dactylus about two-thirds of the length of the hand and meeting the end of the carpal spur, convex and denticulate on the proximal half (fig. 18. $gn.^2$).

First and 2nd peræopods : side-plates wide and irregularly angulated below ; 1st joints reaching below the side-plates, widening distally.

Third and 4th peræopods : 1st joint expanded and rounded behind.

Fifth peræopods : 1st joint expanded behind with the margin subangular above and divided by a series of short transverse ridges into 10 or 11 irregularly angulated spaces (fig. 18. $pp.^5$).

Uropods: the 1st and 2nd have the inner ramus about twice as long as the outer, both styliform; the 3rd are wanting.

Telson entire, concave above, spoon-shaped.

Length 2 millims.

This curious genus was described by Mr. STEBBING from 2 specimens in the Copenhagen Museum, taken by Dr. H. J. HANSEN in the West Indies, and named *A. hanseni.* Mr. A. SCOTT, A.L.S., who was kind enough to dissect, mount, and draw the gnathopods of the very small specimen, informs me that there were 2 oral laminæ, Mr. STEBBING having only observed one. In their general appearance the two species resemble each other, but differ considerably in the structure of the 1st and 2nd gnathopods. I have taken the liberty of naming the present species after the distinguished naturalist, to whom all Amphipodists owe a deep debt of gratitude for the invaluable "Challenger" volumes.

Stenothoë, DANA, 1852.

Stenothoë marina (SP. BATE), var. sinhalensis.

Cheval Paar, 1st March, 1902. One female with young. Length 4 millims.

Differs from the type in its larger eye, in having the penultimate joint of the upper antennæ produced in an infero-distal tooth; the flagellum of the lower antennæ longer than the peduncle; and the absence of spines on the telson.

Stenothoë monoculoides (MONT.).

Tow-nets, Galle, 7th July, 1902, 3 specimens; Cheval Paar, February, 1903, 5 specimens. Length 2·5 millims.

The upper antennæ are about one-fourth longer than the lower; the 3rd joint of the latter is not longer than the 2nd; and the telson has 2 pairs of submarginal spines, but in other respects it agrees with G. O. SARS' description.

Stenothoë gallensis, n. sp.—Plate III., figs. 19.

An abundant species on the Ceylon coast.

Head scarcely produced in a rostrum. Ocular lobe truncate. Eyes round, rather large.

Segments of the mesosome increasing in length successively. Posterior angle of the 3rd pleon segment acute.

Upper antennæ a trifle longer than the lower; 1st and 2nd joints subequal in length, 3rd rather longer than the 1st joint of the flagellum, which has 22 joints in the female.

Lower antennæ: 2nd and 3rd joints subequal; flagellum longer than the peduncle, 18-jointed.

Mouth organs and maxillipeds as in *Stenothoë marina.*

First gnathopods: side-plates small, rounded below; wrist barely half as long as the hand, otherwise as in *S. marina* (fig. 19. gn.[1]).

Second gnathopods (male): very like *S. marina*, but the 3rd joint has the hind margin crenate, with a setule in each notch. Hind margin of the hand straight and densely hirsute; near the base of the dactylus a double-pointed tooth, the proximal point the highest, the irregular distal one with 6 intra-marginal setules. Dactylus as in *S. marina* (fig. 19. gn.² ♂). In the female the posterior margin of the hand is convex, even, with the palm quite undefined, but 4 nearly equidistant spines and some setæ near the middle (fig. 19. gn.² ♀).

First and 2nd peræopods as in *S. marina*.

Third peræopods: side-plate small, produced and rounded behind; 1st joint oval, about half as wide as long, longer than the next 2; 3rd joint but little produced behind; 5th joint nearly as long as the 2 preceding; dactylus strong (fig. 19. pp.³).

Fourth and 5th peræopods as in *S. marina*, hind margin of the 1st joint obscurely crenate.

First uropods reaching to the end of the 3rd; peduncle longer than the rami; rami subequal, a spine in the middle of the inner and 2 or 3 spines in the middle of the outer (fig. 19. ur. ♂).

Second uropods shorter than the 1st and 3rd.

Third uropods: the peduncle longer than the 2 remaining joints, with 5 or 6 spines on the upper margin; the last joint bent upwards in the middle and finely denticulate on the upper margin (fig. 19. ur.).

Telson concave above, oblong, with 4 spines increasing in size distally on the proximal half of each side (fig. 19. ur.).

Length of adult male, 6 millims.; female, with ova, 5 millims.

This species is undoubtedly very near *S. valida*, DANA, 1852, but the dentition of the hind margin of the hand in the male is somewhat different in that species as figured, and the same part in the female is described and figured as having "the palm nearly straight and armed with a stout tooth towards the apex." From *S. marina* it may be distinguished by the relatively short wrist of the 1st gnathopods and the different dentition of the 2nd; the wider 1st joint of the 3rd peræopods; the peculiar structure of the last joint of the 3rd uropods, and the oblong truncate form and armature of the telson.

Perioculodes, G. O. SARS, 1894.

Perioculodes serra,* n. sp.—Plate IV., fig. 20.

Kondatchi Paar and Cheval Paar, November, 1902.

Head as long as the first 3 segments. Rostrum deflexed to the level of the rounded ocular lobe and reaching the end of the 1st joint of the upper antennæ.

First segment of the mesosome twice as long as the 2nd, which is the shortest.

Pleon segments obscurely carinate.

* From the saw-like character of the 1st uropods.

First uropods not reaching the end of the 2nd, outer rami half as long as the inner, *the upper margins of the rami in adults strongly serrate;* 2nd and 3rd uropods subequal in extent, denticulate on the inner and spinous on the outer margins (fig. 20. up.[1]).

Length of adult male, 5 millims.

This species much resembles *P. longimanus* (SP. BATE), the details above indicating the principal points of difference. As is usual with its congener on sandy coasts in the British Seas and Mediterranean, it is found associated with a *Synchelidium*.

Synchelidium, G. O. SARS, 1894.

Synchelidium brevicarpum (SP. BATE).

Kroyera brevicarpa, BATE and WESTWOOD, 'Brit. Sess. Crust.,' App., p. 508.

Cheval Paar, November, 1902, 1 specimen. Length 3 millims.

Agrees with British examples even to the dark brown blotches on the 5th and 6th segments of the mesosome.

Tiron, LILLJEBORG, 1865.

T. thompsoni,* n. sp.—Plate IV., figs. 21.

Kondatchi Paar, 17th November, 1902, 1 specimen; Station LXVI.; 1 female with ova.

Head rounded above, almost as long as the first 3 segments; the front deflexed; ocular lobe rounded; eyes obliterated.

First mesosome segment almost as long as the next 2 and subequal to the 4th. Segments of the pleon and first 2 of the urus slightly carinate, the carinæ produced to teeth which are very conspicuous on the urus, as in *Tiron acanthurus*, LILLJE.

Upper antennæ reaching the end of the peduncle of the lower; 1st joint twice as wide and long as the 2nd, with a long distal spine; 3rd much narrower and almost as long as the 1st; flagellum 6-jointed; appendage reaching the end of the 2nd joint of the flagellum, 3-jointed, the first 2 subequal, the last minute (fig. 21. ant.[1]).

Lower antennæ: 1st joint thick, about half as long as the 2nd, which is subequal to the 3rd; flagellum 6-jointed, shorter than the 2 last joints of the peduncle (fig. 21. ant.[2]).

Maxillipeds: inner plate reaching a little beyond the end of the 1st joints of the palp, the top rounded with plumose submarginal setæ; outer plate membranous, the surface concave, margins irregular and setose; 1st joint of the palp shorter than the 2nd, which is swollen and about as long as the 3rd; dactylus slightly curved, acute (fig. 21. mxp.).

First gnathopods: side-plates widened below, rounded in front, with about 6 submarginal setæ on the lower margin; 1st joint shorter than the next 3, widening distally; wrist rather longer and considerably wider than the hand to which it

* Named after my late friend and fellow-worker, Mr. ISAAC C. THOMPSON, F.L.S.

tapers, 4 pectinate spines and a few long setæ on the hind margin. Hand slightly tapering, with 5 or 6 pectinate spines on the hind margin. Dactylus continuous with the hand and about one-fourth as long, contracting to a curved point beyond the middle (fig. 21. gn.[1]).

Second gnathopods are rather longer than the 1st; the wrist has 4 pectinate spines on the distal half, of which the 2nd and 3rd are longer than the others and have a shorter spine at the base.

First and 2nd peræopods are much shorter than the gnathopods, the 1st joint as long as all the rest; 3rd, 4th, and 5th subequal. Dactylus small and curved, with a seta in the middle of the front margin; a curious strong curved spine rises from the distal end of the anterior margin of the 5th joint and appears to duplicate the dactylus (fig. 21. pp.[1]).

Remaining peræopods are alike; the 1st joint oval; the 3rd much longer and wider than the subequal 4th and 5th, which have the anterior margin spinous and minutely pectinate. Dactylus with a supplementary point.

First uropods extending beyond the 2nd, rami shorter than the peduncle, subequal

Second uropods extending a little beyond the end of the peduncle of the 3rd, outer ramus the shorter.

Third uropods: rami narrow, lanceolate, considerably longer than the peduncle, subequal in extent; the outer spinous on the distal half of the outer margin and with a central row of spines; the inner with the tip truncate and emarginate, with a spine at each angle (fig. 21. up.[3]).

Telson not quite reaching the end of the 3rd uropods, cleft almost to the base, the divisions pointed, tips spinous, a submarginal spine near the distal end of the inner margins (fig. 21. up.[3]).

Superficially very like *T. acanthurus*, LILLJE., but differs in the single dorsal tooth instead of the serrate hind margin of the pleon segments, and in the structure of the maxillipeds, gnathopods, antennular appendage, 3rd uropods, &c.

Eusiroides, STEBBING, 1888.

Eusiroides cæsaris, STEB. var.—Plate IV., fig. 22.

Various localities round Ceylon.

Agrees with the type except as regards the pleon segments, which are not dorsally produced, and the 3rd has the hind margin only slightly convex, with but 3 teeth on the lower third part; the posterior angle is a rounded right angle (fig. 22. pl.[3]). The telson is divided more than half its length.

Length of female with ova 8 millims.

Eusiroides orchomenipes, n. sp.—Plate IV., figs. 23.

In a tube marked "Cheval Paar, February, 1902," with 2 large normal specimens of the last form, was an ovigerous female 5 millims. long. This has the entire hind

epimeral margin of the 3rd pleon segment faintly crenate (fig. 23. pl.[3]), a dorsal carina on the 1st urus segment; the 3rd joint of the last 3 pairs of peræopods about as wide as long and very convex behind; the rami of the 3rd uropods unequal, the outer being much the longer and *with a terminal joint* (fig. 23. ur.). In spite of these very considerable differences, I am disposed to think that sexual maturity has here preceded that of the integument and limbs, which probably require another moult or two to bring them to the fully adult form. I believe this to be a not uncommon condition in the Amphipoda, and one that accounts for a good many so-called species. At the same time it must be admitted that the changes required to make this form identical with *E. cæsaris* are great, and it would almost seem as if it were passing through a Lysianassid form; the 3rd peræopods with their bi-lobed side-plates larger than the wide 1st joint (fig. 23. pp.[3]); their shortness compared to the next 2 pairs, and the structure of the 3rd uropods reminding one of *Orchomene*. On the other hand, the fore part, including head and mouth organs, is distinctly *Eusiroides*. On the whole, I have thought it advisable to record this as a new species, which I would call *E. orchomenipes*.

Paratylus, G. O. Sars, 1894.

Paratylus granulosus, n. sp.

Cheval Paar, 8 specimens.

Body moderately compressed, *the whole integument granulose*. Second pleon segment with a shallow carina slightly produced behind; 3rd segment with a deeper carina produced in an acute tooth.

First segment of the urus as in *P. vedlomensis* (Sp. Bate), *i.e.*, with a small setiferous tooth, a deep depression, and a large arched and pointed hood-like process. Second segment elevated behind. Third peræopods with the 1st joint considerably wider than in *P. vedlomensis*.

Length of male, 4 millims.; female, with ova, rather smaller.

In other respects the animal closely resembles *P. vedlomensis*.

Dexamine, Leach, 1814.

Dexamine serraticrus, n. sp.—Plate IV., figs. 24.

Cheval Paar, 1; Talaivillu Paar, 1. Length 3 millims.

Head as long as the first 3 segments, with a distinct rostrum. Eyes very large, roundish oval, dark; ocular lobe rounded.

Mesosome segments increasing in length successively. Pleon segments carinate, the carinæ produced behind as in *D. spinosa* (Mont.). Hind margin of the 3rd segment concave, the angle produced and upturned. First segment of urus with a prominent carina.

Antennæ subequal, not half as long as the body, like *D. spinosa*.

First and 2nd gnathopods almost alike, the wrist as long as the hand, which is subtriangular, the palm almost rectangularly transverse (fig. 24. gn.[1]).

Peræopods as in *D. spinosa*, *except the last pair, which have the 1st joint expanded behind and coarsely and irregularly toothed or serrate* (fig. 24. pp.[5]).

Telson divided nearly to the base; the divisions truncate at the tips, the outer margin acutely produced, then a spine and 4 minute spinules (fig. 24. t.).

Very near *D. spinosa*, from which it differs in the more transverse palms of the gnathopods, the coarsely serrate and expanded 1st joint of the last peræopods, and the armature of the telson.

Tritæta, BOECK, 1876 (= **Polycheria**, HASWELL, 1880).

Tritæta antarctica, STEBBING*—Plate IV., fig. 25.

Polycheria tenuipes, HASWELL, 'Proc. Linn. Soc. N.S. Wales,' vol. 4. (For further remarks on the synonomy of this species, see "Challenger Report," pp. 451, 512, 945.)

Station XLIX., 7 specimens. Talaivillu Paar, 1. Length of ovigerous female, 3·5 millims.

I have no doubt that these specimens are identical with Mr. STEBBING's species. It is a question, however, whether, owing to the different structure of the terminal joints in the peræopods, this can properly be included in the genus *Tritæta*. In the type, *T. gibbosa* (BATE), the clasping by these limbs is effected by the point of the dactylus meeting the prominent hind margin of the *carpal* joint, and G. O. SARS, in his definition of the genus, says that "the 2 outer joints are modified for grasping," so that unless one may consider the dactylus as one of the 2 joints (in which case the definition is insufficient as regards the type), it does not apply to *T. antarctica*, in which the short dactylus and the somewhat expanded and transverse palm of the propodos form the grasping part (fig. 25. pp.[1]). HASWELL's genus *Polycheria* might be revived if thought desirable.

This species exactly resembles *T. gibbosa* in two respects: its extreme dirtiness and its habit of carrying the antennæ flexed at a right angle from the 2nd joint of the peduncle.

Guernea, CHEVREUX, 1887† (= **Helleria**, NORMAN, 1868‡).

In his definition of the genus *Helleria*, Canon NORMAN writes: "Superior antennæ . . . with secondary appendage"; but his figure of the head and antennæ does not show one.§ CHEVREUX also, in his definition of *Guernea*, writes: "*Antennæ*

* 'Ann. and Mag. Nat. Hist.,' Ser. 4, 1875, vol. 15, p. 184, Plate XVA.

† 'Bull. de la Soc. Zool. de France,' vol. 12, 1887.

‡ 'Ann. and Mag. Nat. Hist.,' December, 1868, p. 418, Plate XXII., XXIII.

§ Canon NORMAN informs me that the words "with secondary appendage" are an accidental error, Monsieur CHEVREUX no doubt took his description from NORMAN's. See also STEBBING, 'Ann. and Mag. Nat. Hist.,' Ser. 6, vol. 5 (1890), p. 192.

superiores flagello appendiculari instructæ": but neither does he show any appendage in his figure (which in my copy is accidentally misplaced and numbered as fig. 1, p. 5). I have not been able to find one either in the species to be described or in British specimens of *G. coalita* (NORMAN). DELLA VALLE ('Gam. d. Golfo di Napoli,' p. 570, Plates 31 and 58) neither figures nor mentions one.

Guernea lævis, CHEVREUX.*—Plate IV., figs. 26.

Station LXVI., Cheval Paar, February; Shoal Buoy, Karativo, February.

Description of female:—

Body tumid. Head longer than the first 2 segments, which are much shorter than the rest, the 5th and 6th being the longest; first 4 side-plates as deep as the segments. Pleon not much longer than the 3 last segments of the mesosome. Urus rather shorter than the last 2 segments of the pleon, the segments coalesced and carinate, *the edge of the carina not denticulate.*

Ocular lobe rather deep, flattened in front, rounded below. Eye large, round; colour red.

Upper antennæ rather longer than the head; 1st joint twice as long as and much wider than the 2nd; 3rd about half as long and thick as the 2nd. Flagellum 4-jointed.

Lower antennæ about as long as the head; 1st joint very short, 2nd longer than the 1st and 3rd united; flagellum very small, about half as long as the 3rd joint. (In the male the 2nd joint is convex below, setose above; the flagellum long and slender, reaching the pleon.)

Mandibles without palps; these organs were not clearly distinguished owing to their small size, but they appear to be of a more complex structure than is shown by DELLA VALLE in *G. coalita.* The remaining mouth organs and maxillipeds seem to agree with DELLA VALLE's figures.

First gnathopods: side-plates oblong, rounded below: the 1st joint much swollen distally, as long as the 3rd, 4th, and 5th together; 2nd and 3rd subequal; wrist as long and almost as wide as the hand, with 4 spines on the hind margin; hand with subparallel margins, a few fine setæ on the hind margin, palm obliquely truncate, defined by 3 long spines, the margin straight, spinous and setose. Dactylus scarcely as long as the palm, with a secondary tooth; a tuft of long setæ at the base (fig. 26. gn.[1]).

Second gnathopods very like the 1st, but rather longer and more slender in all the parts; the 1st joint with 3 long setæ on the hind and about 6 short setules on the front margin.

First and 2nd peræopods: side-plates oblong, rounded below; 1st joint with subparallel margins, about as long as the next 3; 4th joint with 4 spines on the hind margin, increasing in length distally.

* 'Crust. Amph. de S. O. Bretagne,' p. 41 (separate copy), Note.

Third peræopods: side-plates broad; 1st joint expanded before and behind, as wide as the side-plate, the front margin setose; 3rd joint longer and twice as wide as the 4th; 5th about as long as the 3rd (fig. 26. pp.[3]).

Fourth peræopods like the 3rd.

Fifth peræopods: side-plates much smaller than the 1st joint, which is much expanded behind, straight in front; 3rd joint widening somewhat distally and produced at the posterior angle; 4th shorter and narrower than the 3rd, oblong, narrowing distally; both these joints densely setose and spinous on the front and sparsely on the hind margin; 5th joint as long as the 4th, very slender, naked. Dactylus small, in a straight line with the 5th joint. The setæ on the 3rd and 4th joints are simple, *i.e.*, not plumose (fig. 26. pp.[5]).

First uropods extending beyond the 2nd and these beyond the 3rd; rami of the 1st hardly as long as the peduncle; inner ramus of the 2nd shorter than the outer; rami of the 3rd pair wider than the others, about twice as long as the peduncle, without setæ or spines.

Telson divided almost to the base with a setule at the tip of each division.

Length of female with ova 2 millims.

The most conspicuous difference between this species and *G. coalita* is the smoothness of the dorsal surface of the urus, but there are also differences in the form and armature of the limbs. Both NORMAN and DELLA VALLE have described male specimens; besides the shorter lower antennæ and absence of plumose setæ on the 3rd uropods, there is a curious difference in the relative proportions of the mesosome segments in the 2 sexes of both species.

Hornellia,* n. gen.

Body rather tumid. Segments of pleon and urus with postero-dorsal teeth.

Head not rostrate or vaulted in front. Eyes distinct, not coalescent.

Upper antennæ with an appendage; flagellum slender, much longer than the peduncle.

Mandibles with well-developed molar tubercle, spine-row, and toothed cutting edges; palp long, 3-jointed, 2nd and 3rd joints subequal (fig. 27. m.).

First maxillæ with the 2nd joint of the palp widened towards the obliquely truncate end, which is crowned with spine-teeth and setæ alternately (fig. 27. mx.[1]).

Maxillipeds well developed in all parts; 4th joint of palp dactyliform (fig. 27. mxp.).

Gnathopods subequal and similar, like those in *Halimedon*.

Third uropods of moderate length, with subequal rami.

Telson long and deeply cleft.

This genus will probably find a place in the as yet undefined family Melphidippidæ, STEBBING.

* See footnote, p. 258.

Hornellia incerta, n. sp.—Plate IV., figs. 27.

Station LIII., 4 or 5 : off Chilavaturai. 4 ; Cheval Paar.

Description of female with ova.

Head as long as the first 2 segments, which, as well as the head, are shorter in the male. Eyes large, wide-oval, red.

Second and 3rd pleon and 1st and 2nd urus segments postero-dorsally dentate, the teeth subequal. Hind margin of the epimere of the 3rd pleon segment rather concave, the angle produced and acute.

First segment of the urus dorsally depressed, twice as long as the 2nd or 3rd.

(In the male the teeth on the hind margins of the segments and the dorsal depression are more conspicuous than in the female.)

Upper antennæ more than half as long as the body, the peduncle scarcely half the length of the flagellum ; the 1st joint considerably wider and longer than the 2nd, which is more than twice as long as the 3rd ; flagellum slender, 14-jointed ; appendage 2-jointed, the 1st the longer.

Lower antennæ imperfect in all the specimens. In the male the 2nd joint is as wide as the 1st of the upper antennæ, and reaches to the 3rd joint of the upper flagellum ; it is densely setose above.

Mandibular palp projecting beyond the end of the 1st joint of the upper antennæ.

First gnathopods : side-plates oblong, deeper than wide, expanding below with marginal setules and intramarginal setæ. Wrist as long and wide as the hand, being much widened behind : hand oval, widest near the base ; palm scarcely defined by 2 sets of spines ; the 3rd, 4th, and 5th joints are furnished with many long spines, of which many are pectinate ; dactylus slender, about two-thirds the length of the hind margin of the hand (fig. 27. gn.[1]).

Second gnathopods nearly resembling the 1st, but rather larger ; the spines fewer and simple. The coxopodite is remarkably large and distinct in both the gnathopods.

First and 2nd peræopods : side-plates of the 1st as in the gnathopods ; of the 2nd much wider below and sloped away behind ; 1st joint rather longer than the 2 next, narrow, slightly curved ; 3rd joint somewhat dilated behind, subequal to the 5th, the 3rd shorter. Dactylus strong, slightly curved. A few slender spines on all the joints.

Remaining peræopods imperfect : the 1st joint about twice as long as wide, sub-ovate : the 3rd joint about as long as the 1st.

First uropods long. slender, and spinous ; rami and peduncle all subequal.

Second uropods : outer ramus as long as the peduncle, the inner about one-fourth longer : both spinous.

Third uropods : narrow, lanceolate ; the inner ramus rather longer than the outer and twice as long as the peduncle.

Telson cleft almost to the base, each division notched at the tip, the outer angle of the notch longer and wider than the inner (fig. 27. t.).

Length of female with ova. 3 millims.

Melita, Leach, 1813.

Melita obtusata (Montagu).

Stations V., XVII., XXIII., XLIII., LIII., LXIV.

Females only.

Melita anisochir (Kröyer).—Plate IV., figs. 28.

Gammarus anisochir, Kröyer, 1845.

Melita cotesi, Giles, 'Journ. Asiatic Soc., Bengal,' 1890, vol. 59, p. 64, Pl. ii., fig. 1.

It is probable that the following species ought also to be referred to *M. anisochir*, viz., *M. valida* (Dana), *M. setipes* (Dana), and *M. australis*, Haswell. According to Della Valle all these should be referred to *Gammarus fresnelii*, Audouin and Savigny, 1825.

This is an abundant species all round Ceylon.

Description of female :—

Head longer than the first 2 segments of the mesosome, which increase in length progressively. Eyes large, round, red.

Pleon segments with dorsal teeth on the hind margin, the teeth increasing in size posteriorly ; the 1st has 4 subequal teeth, the 2nd and 3rd 6 unequal ; the epimeral hind margin of the last is concave, with marginal setules, the posterior angle produced and acute (fig. 28. pl. & ur.).

The 1st urus segment has a small central tooth, with a large and a small one below it ; there is a dorsal indentation on the anterior part ; the 2nd segment, which is the shortest of the three, has a small central tooth, with a long spine and 2 minute subdorsal teeth on each side ; the 3rd segment has a conical tooth just above the base of the telson. The number and proportions of the teeth, especially in the pleon segments, vary considerably (fig. 28. pl. & ur.).

Upper antennæ nearly as long as the body, the 1st joint twice as wide and two-thirds as long as the 2nd, lower margin convex, with 2 or 3 subcentral and a distal spine ; 2nd joint 4 times as long as the 3rd. 1st joint of the flagellum as long as the next 2. Appendage varying in the number of joints, generally 3 subequal, with a minute terminal, reaching beyond the end of the 3rd joint of the flagellum.

Lower antennæ about two-thirds of the length of the upper and stouter than these, except the 1st joint.

Mouth organs normal ; the 3rd joint of the mandibular palp is rather longer than the 2nd.

First gnathopods : side-plates oblong, with rounded angles, wider below, with marginal setules ; 1st joint widening distally, as long as the next 3 ; wrist longer than and fully as wide as the hand, with many short and a few long setæ on the hind margin ; hand widely oval, palm undefined, hind margin very convex and setose like the wrist. Dactylus about half as long as the hand (fig. 28. gn.[1]).

Second gnathopods larger than the 1st ; side-plates oblong, not wider below ;

1st joint subequal in length and width to the hand, which is rather longer than the wrist, front and hind margins subparallel, slightly convex; palm oblique, well defined, uneven and setose (fig. 28. gn.[2] ♀).

First and 2nd peræopods: 1st joint widening abruptly. Dactylus strong, with a secondary tooth on the outside and a short spine on the inside (fig. 28. pp.[1]).

Third peræopods: 1st joint oblong and subequal in length to the 5th.

Fourth and 5th peræopods much more powerful than the 3rd, and reaching backwards much beyond the ends of the uropods; the joints spinous. All the peræopods have the secondary tooth on the dactylus.

First uropods extending a little beyond the 2nd, slender; peduncles and rami subequal, spinous; 2nd pair resembling the 1st.

Third uropods with the outer ramus about twice as long as the peduncle, with 3 "whorls" of spines between the base and the extremity; inner ramus quite rudimentary.

Telson not unlike that of *M. palmata* (MONT.), but the divisions are sharply pointed without terminal spines, but with a long upright one at the angle on the inner side, and a horizontal one between it and the point.

Length 5 millims.

The male has been described and figured by Dr. GILES (*loc. cit.*). It is remarkable for the large size and peculiar form and colouring of one of the 2nd gnathopods. I think there can be little doubt, from its resemblance to a bit of broken shell, that its use is protective, the animal covering itself with it as it lies partly buried in the sand. Dr. HERDMAN informs me that he has seen them in this position.

Mæra, LEACH, 1813.

Mæra othonides, n. sp.—Plate V., figs. 29.

Stations V., LIII., LXIV., Cheval Paar.

Very near *M. othonis* (M. EDWARDS), from which it differs as follows:—

The ocular lobe is *rounded*.

The 3rd pleon segment has *no teeth on its lower* and from 1 to 3 teeth on the hind margin (fig. 29. pl.[3]).

The appendage of the upper antennæ is 3-*jointed*.

The palp of the mandibles has the 3rd joint *considerably shorter than the 2nd*.

The side-plates of the gnathopods are *not serrated* below; there is a single tooth at the posterior angle of the 1st pair. In the hand of the 2nd pair in the female the palm is concave.

The 3rd uropods have their ends *truncate* with a group of spines (fig. 29. up.[3]).

The telson has a *second notch* above the terminal one on the inside of each division (fig. 29. t.).

Length 8 millims.

Of the above characters the least valuable is that of the 3rd pleon segment, as the number and position of the teeth vary considerably.

Mæra rubro-maculata (STIMPSON).—Plate V., fig. 30.

Gammarus rubro-maculatus, STIMPSON, 'Proc. Acad. Nat. Sci.,' Philadelphia, 1855.

M. rubro-maculata (STIMPSON), '"Challenger" Amphipoda,' p. 1008, Plates XCV., XCVI.

Ceradocus rubro-maculatus (STIMPSON), DELLA VALLE, 'Gamm. d. Golfo di Napoli,' p. 720.

From Kodramallai Point southward to Galle.

Length of adult male 10 millims.

In the specimen dissected, the mandibular palp was set far back, the 1st joint produced forward in a sharp point; the 2nd widened abruptly near the base, then narrowing gradually (fig. 30. m.).

Mæra tenella (DANA).—Plate V., figs. 31.

Gammarus tenellus, DANA, 'U.S. Explor. Expn.,' p. 952, Plate 65, fig. 7.

Mæra tenella, SP. BATE, 'Cat. Amph. Crust. Brit. Mus.,' p. 193, Plate XXXV., p. 3.

Cheval Paar, 10th November, 1902. One male, length 6 millims.

Head about as long as the first 2 segments. Eye nearly round, rather small.

Mesosome and pleon without dorsal teeth; epimere of the 3rd pleon segment with 6 or 7 unequal teeth on the hind margin, the posterior angle acute and somewhat upturned (fig. 31. pl.^{3}). First segment of the urus with 3 small postero-dorsal teeth and a dorsal depression; 2nd segment with 1 tooth.

Upper antennæ reaching to the end of the pleon; 1st joint twice as thick and nearly as long as the 2nd; 3rd very short; flagellum rather shorter than the first 2 joints of the peduncle, 13-jointed; appendage 8-jointed, two-thirds of the length of the flagellum.

Lower antennæ scarcely reaching beyond the end of the peduncle of the upper; the flagellum about as long as the 3rd joint.

Both upper and lower antennæ are sparsely setose, except the flagellum of the lower, which is more hairy.

First gnathopods: side-plates small, produced in front to an acute angle; wrist longer than the hand, the hind margin densely setose; hand with the palm ill-defined, and transverse rows of setæ on the hind margin (fig. 31. gn.^{1}).

Second gnathopods: side-plates small, quadrate, with rounded angles; 1st joint stout, two-thirds of the length of the hand and nearly twice as long as the next 3 joints together; wrist transverse; hand large, widening distally; hind margin as long as the front, straight, with a few setæ, and ending in a strong curved tooth which defines the palm; this is transverse, convex, uneven, and spinulose (fig. 31. gn.^{2}).

First and 2nd peræopods slender, slightly longer than the 1st gnathopods; 1st joint

narrow, subequal to the next 2; 5th longer than 4th and not so long as 3rd; 2 distal spines on the hind margin of the 4th and a row of 4 on that of the 5th joint. Dactylus with a strong tooth behind the point (fig. 31. pp.[2]), giving it the appearance of being bifid (fig. 3K, Sp. Bate, *loc. cit.*).

The rest of the peræopods are altogether wanting.

The 1st and 2nd uropods are subequal in extent, not quite reaching the middle of the outer ramus of the 3rd pair; the rami are subequal; in the 1st they are rather shorter and in the 2nd rather longer than the peduncles; all spinous on both margins, with groups of terminal spines.

Third uropods: peduncle little more than half as long as the outer ramus, which is but little longer than the inner and has 4 deep notches with fascicles of long spines on the outer margin; both are truncate, with groups of long spines at the ends (fig. 31. up.[3]).

Telson small, cleft to the base, and widely dehiscent, each division ending in a double point with 2 long and 2 or 3 short spines (fig. 31. t.).

Dana's specimen was from the Fiji Islands. This species has a strong general resemblance to the next, from which, however, it differs in the toothed epimeres of the 3rd pleon segment; the relatively longer and more equal 3rd uropods; the different form of the dactyli of the 1st and 2nd peræopods, &c. It is unfortunate that the specimen had lost the last 3 pairs of peræopods, as these have a very distinctive character in *M. scissimana.*

Mæra scissimana (Costa)—Plate V., fig. 32. pp.[1].

Gammarus scissimanus, A. Costa, 1853.

Mæra truncatipes (White), Della Valle, *loc. cit.*, p. 725, Plate 22.

West Coast of Ceylon.

Length 5 millims.

This species forms a connecting link between the genera *Mæra* and *Elasmopus.* The fore part, including the 3rd peræopods, is typical *Mæra*, while the massive and very spinous 4th and 5th peræopods (a character that is much more marked in Ceylon than in Mediterranean specimens), and the comparatively short rami of the 3rd uropods, resemble *Elasmopus.* Another peculiarity of the species is that the size and shape of the hand of the 2nd gnathopods is much the same in males and females.

Mæra tenuicornis (Dana)—Plate V., figs. 33.

Melita tenuicornis, Dana, *loc. cit.*, p. 963, Plate 66, fig. 5.

Mæra tenuicornis, Sp. Bate, 'Cat. Amph. Crust. Brit. Mus.,' p. 195, Plate XXXV., fig. 6.

Tow-net off Marichchikadi, 1st February, 1903. One male, and one young.

Segments of the mesosome and pleon without carinæ or dorsal teeth. Hind margin of the 3rd pleon epimere concave, smooth; lower margin rather convex,

obscurely toothed; posterior angle acute (fig. 33. pl.[3]). First segment of urus with a double carina produced backwards in 2 points; 2nd segment with a small tooth and a long upright spine (fig. 33. ur.).

Upper antennæ: 1st joint stout, two-thirds as long as the 2nd and about twice as long as the 3rd. Flagellum long and slender, broken at the 18th joint. Appendage small, with 2 subequal joints and a minute terminal one, barely reaching the end of the 1st joint of the flagellum.

Lower antennæ: peduncle reaching a little beyond that of the upper; 1st joint short, 2nd and 3rd subequal in length, but the 2nd much the wider; flagellum shorter than the last 2 joints of the peduncle.

Mandibles as in *Elasmopus subcarinatus* (*vide* '"Challenger" Amph.,' Plate 98, *E. persetosus*), but the 2nd joint of the palp is subequal to and rather wider than the 3rd; very few setæ (fig. 33. m.).

First maxillæ: the inner plate oblong, with 7 plumose terminal setæ (fig. 33. mx.[1]).

Maxillipeds as in *E. persetosus*, but the outer plate reaching the end of the 2nd joint of the palp.

First gnathopods: side-plates subtriangular, with rounded angles; 1st joint stout, margins parallel, as long as the 3rd and 4th united; 2nd and 3rd subequal. Wrist nearly twice as long and about as wide as the hand. Hand widening distally, the hind margin straight, the front convex and bent at the distal end at a right angle round the base of the dactylus in a tooth-like process reaching beyond the middle of the dactylus, and having the appearance of a 2nd dactylus; the hind margin ends in a densely spinous lobe. The dactylus is very small, crooked, and deeply sunk in the hand. The whole limb is setose and recalls the 2nd gnathopod of a *Lysianax* (fig. 33. gn.[1]).

Second gnathopods: side-plates deeper than wide, oblong, rounded and a little wider below, about as long as the 1st joint; this is rather longer than the next 3 joints, but shorter than the hand; 2nd and 3rd joints subequal. Wrist triangular, about as wide as long; the hind margin with about 8 setiferous ridges. Hand long-oval, widest about one-third of its length from the base; palm undefined, the hind margin densely clothed on the distal half with incurved plumose setæ. Dactylus fully half as long as the hind margin (fig. 33. gn.[2]).

First and 2nd peræopods: side-plates fully as deep as the segments, rounded below; hind margin of the 2nd pair concave. The entire limb is as long as the last 2 pairs of peræopods, in which respect they differ from DANA's description and figure; 1st joint as long as the 3rd and 4th united; 3rd longer than 4th; 4th and 5th subequal, a few small spines on their hind margins; the rest of the limb has only a few scattered setæ (fig. 33. pp.[2]).

Remaining peræopods of similar form, the 3rd rather the shortest; 1st joint wide-oval, the width more than half the length, the hind margin smooth, front margin with small spines; 2nd joint short; 3rd joint very wide, 3 times as wide as the 4th, with

long spines on setæ, before and behind; 5th joint three-quarters of the length of the 3rd and 4th together. Dactylus rather small, curved at the point (fig. 33. pp.[1]). In the 3rd pair the hind margin of the 1st joint is straight, in the 4th and 5th convex.

First uropods: rami subequal, shorter than the peduncle; all spinous.

Second uropods like the 1st, but the rami rather longer than the peduncle.

Third uropods wanting.

Telson cleft almost to the base, the divisions pointed with an angle on the inside.

Length 5 millims.

There are certain discrepancies between our specimens and DANA's description and figures of the New Zealand form, as given by SP. BATE. I attach no importance to the omission of the antennular appendage, as this is small and not easy to see. But if we are to take the proportions of the first 2 and last 3 pairs of peræopods shown in the figure as even approximately correct, they are quite different from ours. On the other hand, the 1st gnathopods are so peculiar and the description and figures of both pairs agree so well, that I feel justified in considering them identical. The species requires a new genus, but the absence of the 3rd uropods makes a satisfactory definition impossible.

Elasmopus, COSTA, 1856.

The mandibular palp in this genus is of two distinct forms; the one (A) with the 3rd joint slender, its hind margin straight, and its front margin rather sparsely setose or naked, approaching the same appendage in *Mæra*, *e.g.*, *M. obtusata* (MONT.); the other (B) as in *E. rapax*, COSTA, with the 3rd joint strong, the hind margin convex and the front margin pectinate.

To (A) belong, of the species under consideration,

E. subcarinatus (HASWELL) = *E. persetosus*, STEBBING.

To (B) belong the new species *E. serrula*, *E. spinimanus*, and *E. dubius*.

(A) **Elasmopus subcarinatus** (HASWELL)—Plate V., figs. 34.

Megamæra subcarinata, HASWELL, 'Proc. Linn. Soc. N.S.W.,' vol. 4, p. 335, Plate XXI.
E. subcarinata (HASWELL) (**E. persetosus**, STEBBING), '"Chall." Amph.,' p. 1019, Plate XCVIII.

Abundant and occurs all round Ceylon.

Length of adult male 7·5 millims.

The antennular appendage is 2-jointed instead of 6, otherwise it agrees with the "Challenger" description, except in the sculpture of the hand of the 2nd gnathopods of the male, which varies considerably. In the smaller specimens there is generally a single flat-topped lobe near the base of the dactylus; in the larger this is divided in two by a sinus. In the largest of all there is hardly a trace of a lobe or tooth on any part of the hind margin, which is densely setose in all (figs. 34. gn.[2] ♂ and ♀). None are quite like the "Challenger" drawing. The 3rd joint of the mandibular palp is distinctly longer than the 2nd.

(B) **Elasmopus dubius**, n. sp.—Plate V., figs. 35.

One male from pearl oysters, East Cheval Paar, 8th November, 1902.

Body smooth, without dorsal teeth.

Head: ocular lobe rounded, with an acute, re-entering angle and a narrow rounded lobe below, as in *E. rapax*. Eyes large, wide-oval, dark.

First 4 side-plates about as deep as the segments.

Upper antennæ of moderate length; the 1st joint as long and twice as thick as the 2nd and about one-third longer than the 3rd. Flagellum 16-jointed, a little shorter than the peduncle. Appendage 2-jointed, the 2nd rather the longer, a little longer than the 1st joint of the flagellum.

Lower antennæ reaching the end of the peduncle of the upper, 2nd and 3rd joints subequal; flagellum 8-jointed, rather longer than the last joint of the peduncle.

Mouth organs as in *E. rapax*.

Maxillipeds as in *E. rapax*.

First gnathopods: side-plates irregularly rhomboidal, the anterior angle rounded, with a few setæ on the lower margin. First joint about as long as the next 3; wrist rather shorter than the hand, the hind margin densely setose; hand with the palm rounded off into the hind margin, but defined by a spine (fig. 35. gn.[1]).

Second gnathopods: side-plates rounded below, not reaching half-way down the 1st joint; this is longer than the next 3; 3rd joint produced behind in a narrow lobe with 5 or 6 setæ; wrist very short and wide, hind margin with a dense tuft of setæ. Hand nearly twice as long as the 1st joint, margins subparallel and subequal, the front slightly the longer and smooth, except 2 or 3 setules; the hind margin has 9 or 10 fascicles of setæ and ends in a strong tooth which defines the palm; this is transverse, not oblique, narrow, with a central tubercle; the hinge of the dactylus is as wide as the palm. *Dactylus peculiar, bulbous at the base and very strong, with a curved blunt point which meets the defining tooth of the hind margin* (fig. 35. gn.[2]).

First and 2nd peræopods almost as long as the 4th and 5th; 1st joint narrow, as long as the 3rd and 4th together; 4th and 5th spinous on the hind margin.

Third peræopods wanting.

Fourth and 5th peræopods subequal and similar, stout; 1st joint five-sixths as wide as long, hind margin serrate, front spinous; 3rd joint produced downwards *in front;* otherwise subequal to 4th and shorter than 5th; all the joints spinous. Dactyli strong (fig. 35. pp.[5]).

First uropods: rami subequal, shorter than the peduncle; all spinous.

Second uropods short and stout; outer ramus shorter than the inner and subequal to the peduncle; all spinous.

Third uropods wanting.

Telson reaching beyond the middle of the 2nd uropods, divided nearly to the base, the divisions notched at the tip with a long and a short spine in each notch.

Length 5 millims.

This species is certainly very near *Mæra festiva*, CHILTON, 'Proc. Linn. Soc., N.S.W.,' vol. 9, Part 4, p. 3, Plate XLVI., fig. 2. As, however, Professor CHILTON has only described the antennæ and gnathopods, and as both of these differ somewhat from the specimen described above (considering also the distance between Sydney and Ceylon), it seems better to consider them as distinct. It is unfortunate that, in both cases, the 3rd uropods, so important in this family, should be wanting.

Elasmopus spinimanus, n. sp.—Plate V., figs. 36.

Reef, Galle, Station XXXVIII.

Very near *E. rapax*, from which it differs in the following points :—

The hind margin of the epimere of the 3rd pleon segment is slightly concave, the lower margin convex with submarginal spines, the posterior angle upturned, acute (fig. 36. pl.^{3}).

The 1st gnathopods have the hand longer than the wrist, the palm very oblique and only defined by a spine. The anterior angle of the side-plates is rounded.

The hand of the 2nd gnathopods in the male has no tubercle, except near the base of the dactylus; *this is flat-topped and crowned with 7 or 8 spines; below this is a row of 6 spines on the distal third of the hind margin*, with rather scanty fascicles of setæ below this. The side-plates are rounded below (fig. 36. gn.^{2}. ♂). In the female the limb nearly resembles that of *E. rapax*, female.

The last 3 pairs of peræopods are more slender than in *E. rapax*; the 1st joint with the hind margin obscurely serrate, and in the 3rd pair concave.

The 3rd uropods have the rami subequal in length and breadth, and considerably longer (as 5 : 3) than the peduncle, the outer with 4 fascicles of spines on the outer margin (fig. 36. up.^{3}).

The divisions of the telson are narrower at the end and more deeply notched.

Length 5 millims.

From *E. affinis*, DELLA VALLE, it differs in the absence of the median tubercle and the presence of the 6 spines on the hind margin of the hand of the 2nd gnathopods.

Elasmopus serrula, n. sp.—Plate VIII., figs. 37.

Galle; basket hung to buoy, 9th May, 1902, 1 male; from pearl oyster washings, Cheval Paar, several.

This species resembles *E. rapax* in the form and character of the body, the head, antennæ, mouth organs, peræopods (so far as relates to their proportions), and uropods.

The 3rd pleon segment has the hind margin almost straight, the lower convex and the posterior angle a little produced and upturned.

The side-plates of the first gnathopods have the front margin concave and the angle rounded; the limb as in *E. rapax*.

The 2nd gnathopods in the male have the hand of similar form to *E. rapax*,

but *the hind margin is without spines or dentiform projections, except the large flat-topped one* (as in the last species) *at the base of the dactylus;* it is densely clothed with long setæ rising from numerous transverse ridges (fig. 37. gn.[2]). In the female the hand resembles *E. rapax*.

The 3rd peræopods are very short and stout, the hind margin of the front joint almost straight, narrowing distally, and obscurely toothed.

The 4th and 5th peræopods are subequal; the 1st joint, which is rather wider and more convex in the 5th, *has the greater part of the hind margin elegantly cut into flat-topped teeth* of a peculiar form (fig. 37. pp.[4]).

The telson has the end of the divisions rather deeply notched, with the angles equally produced; 2 unequal spines and 2 spinules in each notch (fig. 37. t.).

Parelasmopus, STEBBING, 1888.

Parelasmopus suluensis (DANA).—Plate VI., figs. 38.

> **Gammarus suluensis**, DANA, 'U.S. Exploring Expedition,' 1852.
> **Megamæra suluensis**, SP. BATE, 'Cat. Amph. Crust. Brit. Mus.,' 1862.

Cheval Paar, Gulf of Manaar.

The palm of the 2nd gnathopod in the male is much less oblique than in the "Challenger" figure.* In the female this limb resembles the 1st gnathopods, except in being rather longer and more slender. The hand is considerably longer and narrower than the wrist, with 5 fascicles of setæ on each margin; palm very oblique (fig. 38. gn.[2]).

The 3rd uropods (wanting in the "Challenger" specimen) have the rami half as long again as the peduncle, subequal in length and width, the outer slightly the longer, with 4 spiniferous notches on the outer edge; the inner has 4 pairs of submarginal spines on the inner side (fig. 38. up.[3]).

The telson reaches to the end of the peduncle of the 3rd uropods.

The length of a female (tube 94) is 13 millims.

Cheirocratus, NORMAN, 1865.

A single female with ova from Periya Paar Kerrai, November, 1902; length 4 millims. There was only one postero-dorsal tooth on the urus and that on the 1st segment. A description without the male would be useless.

Megaluropus, NORMAN,† 1889.

Megaluropus agilis, NORMAN.

> **Cheirocratus drechselii**, MEINERT, 'Crust. Malacostr. Daniæ,' 1890.
> **Megaluropus agilis**, NORMAN, DELLA VALLE, *loc. cit.*, p. 695, plates 3 and 34.

Kondatchi and Cheval Paars, November, 1902. About 30 specimens.

Notwithstanding the following differences between the Ceylon and English speci-

* In this respect our specimens resemble *P. setiger*, CHEVREUX ('Mém. de la Société Zool. de France,' t. xiv., p. 412, fig. 32, 1901), as also in some other small details.

† 'Ann. and Mag. Nat. Hist.,' Ser. 6, vol. 3 (1889), p. 446, Plate XVIII., and vol. 4, p. 123.

mens, I consider them to be substantially identical. In the former the denticulation of the hind margin of the 3rd pleon segment is finer; the flagellum of the upper antennæ is 9-jointed and considerably *longer* than the peduncle in the female; the last 3 pairs of peræopods have the 1st joint narrower, the hind margin concave, obscurely serrate, and produced downwards.

Length barely 4 millims.

To illustrate the difficulties one has to contend with in determining species from specimens sent from abroad in spirit, I may mention that of the 30 odd specimens only one had the lower antennæ, and perhaps 5 or 6 the broad 3rd uropods. It would be far better if specimens, when picked out, were sent home in *pure* glycerine.

Lilljeborgia, Sp. Bate, 1862.

Lilljeborgia pallida, Sp. Bate.

L. pallida, Bate, Norman, 'Ann. and Mag. Nat. Hist.,' Ser. 6, vol. 4 (1889), p. 116, plate x.
L. pallida, Bate, G. O. Sars, 'Amph. of Norway,' p. 530, plate 187.
Nicippe pallida (Bate), Della Valle, *loc. cit.*, p. 658, plate 19.

Stations XIX., LI. Length 4·5 millims.

Lembos,* Sp. Bate, 1857 (= **Autonoë**, Bruzelius, 1859, in part).

Lembos podoceroides, n. sp.—Plate VI., figs. 39.

Coast of Ceylon, under 100 fathoms, generally distributed.

Head as long as the first 2 segments; ocular lobe as in *L.* (*Autonoë*) *websteri*, Bate. Eye round-oval, dark.

Third segment of the pleon, with the hind and lower margins of the epimere convex, the posterior angle subacute and produced; a diagonal line running forward and upward from it (fig. 39. pl.[3]).

First segment of the urus almost as long as the remainder, including the telson.

Upper antennæ reaching to the pleon, peduncle reaching about the middle of the last joint of that of the lower; 1st joint about 3 times as wide and three-fourths as long as the 2nd, and 3 times as the 3rd. Flagellum about 22-jointed in the male, the joints lengthening distally. Appendage 7-jointed, the last minute, reaching the 7th joint of the flagellum.

Lower antennæ reaching to the middle of the flagellum of the upper; 2nd and 3rd joints subequal; flagellum in female 5-jointed, shorter than the last joint of the peduncle. Both pair of antennæ very sparsely setose.

Mandibular palp large and projecting, the 3rd joint as long as the 1st and 2nd united; the 2nd expanded distally (fig. 39. m.).

First gnathopods in the female (fig. 39. gn.[1] ♀):—

Side-plates rhomboidal, shorter than the 1st joint, the anterior angle blunt; 1st joint stout, rather longer than the next 3; wrist about half the length of the

* For the reasons for re-instating this genus see Stebbing, 'Ann. and Mag. Nat. Hist.,' Ser. 6, vol. xvi., 1895, p. 206.

hand, hind margin convex and setose. Hand wider than the wrist and widening distally, the palm about half as long as the hind margin, oblique, with a shallow sinus above the palmar angle, below which is a strong spine; the hind margin, palm, and sides of the hand and wrist are furnished with fascicles of setæ. The dactylus has the inner margin serrate and reaches below the strong spine mentioned above.

In young male: side-plates with the anterior angle acute; the first 4 joints very stout, the 1st about half as long as the hand and longer than the next 3; wrist about one-fourth of the length of the hand; the front margin of this is convex and naked; the hind margin has near the base a strong, somewhat everted tooth, above which is an angular sinus; above this is a flat-topped projection, with a rough edge and submarginal setæ, and a small sinus near the base of the dactylus: this has a central projection on the inner side which corresponds with the flat-topped one; the point reaches slightly beyond the basal tooth; the outer margin is rough with minute granules, as also is the lower margin of the basal tooth (fig. 39. gn.[1] ♂ jr.).

In adult male: the first 4 joints as in the young male, except the 1st joint, which is wider, being half as wide as long. The hand has the base produced backwards in a long pointed spur, above which the hind margin is straight, with a small semicircular sinus near the hinge of the dactylus; the latter is relatively much longer than in the young male, evenly curved like a sabre, without the central projection, and with a row of 7 or 8 setules along the inner margin (fig. 39. gn.[1] ♂ adult).

The 2nd gnathopods are as usual in this family small and alike in both sexes, except that in the female the wrist is rather shorter and in the males subequal to or slightly longer than the hand; of this the margins are subparallel, the palm obliquely transverse. This limb and the rest of the animal so closely resemble *L.* (*Autonoë*) *websteri*, SP. BATE, that I refer my readers to Professor G. O. SARS' excellent description and figures ('Amph. of Norway,' p. 547, plate 194).

Length 8 millims.

The resemblance between the *first* gnathopods of the young and old males of this species and the *second* gnathopods of the same in *Jassa* (*Podocerus*) *falcata* (MONT.) is very striking (*conf.* SARS, *loc. cit.*, plate 212, p^2 ♂–p^2 ♂′).

Lembos chelatus, n. sp.—Plate VI., figs. 40.

One specimen from north end of Chilaw Paar, 2nd February, 1902.

Head longer than the first 2 segments. Ocular lobe prominent, angular. Eye roundish, large, dark.

Third pleon segment rounded behind.

Upper antennæ: peduncle shorter than that of the lower; 1st joint twice as thick and more than half as long as the 2nd; the 3rd rather shorter than the 2nd; 1st joint of the flagellum almost as long as the last of the peduncle; appendage very small, 2-jointed, about one-third of the 1st joint of the flagellum. The flagellum was broken at the 2nd joint.

Lower antennæ reaching the 4th body segment; the 2nd joint rather shorter than the 3rd; flagellum subequal to these united.

Mandibular palp with the 3rd joint shorter and wider than the 2nd, sub-oval, widest near the distal end, which is truncate; 1st joint very short (fig. 40. mp.).

First maxillæ: inner plate minute, with a single setule near the rounded top.

Palps of the maxillipeds more slender than in *L. websteri*, the outer plates reaching about the middle of the 2nd joint, armed with spine-teeth which increase in length distally.

First gnathopods: side-plates fully as deep as the segments, wider below, the angles rounded; 1st joint about twice as long as the next 3, rather shorter than the hand; 3rd joint rounded behind; wrist small, triangular, almost coalescent with the base of the hand; this has the front and hind margins subparallel and sparsely setose; the latter produced in a strong tooth beyond the base of the dactylus to the point of which it is opposed, forming a chela; a smaller tooth between this and the base of the dactylus; this has a prominent rounded tooth on the inner margin (fig. 40. gn.^{1}).

Second gnathopods: side-plates irregularly rhomboidal, with rounded angles; 1st joints stronger than in the 1st pair, wider than any of the other joints, and about as long as the hand; this is a little longer than, and subequal in width to, the wrist, margins parallel, setose; palm small, oblique. Dactylus reaching much beyond the palm (fig. 40. gn.^{2}).

First and 2nd peræopods: side-plates rounded below, deeper than the segments; 1st joint relatively wide, 3rd nearly twice as long as the 4th, and wider at the distal end; the whole very sparsely setose (fig. 40. pp.^{1}).

Third peræopods but little longer than the 2nd; 1st joint widely oval and about as long as the next 3; 3rd longer than 4th, the two together rather longer than the 5th, which is slender, and has 2 or 3 spines on the front margin.

Fourth and 5th peræopods are subequal, the latter shorter than is usual in this genus, only reaching the 2nd urus segment; they are but little longer than the 3rd pair, which they resemble, except the 1st joint, which is relatively shorter and narrower (fig. 40. pp.^{5}); the 3 pairs are almost entirely without setæ.

The 3rd uropods extend a little beyond the 2nd, and these beyond the 1st; the outer ramus of the 3 pairs is shorter than the inner; in the 3rd the inner ramus is as long as the peduncle, with a spine near the middle and 3 unequal terminal spines; the outer has 2 or 3 short and 2 or 3 long terminal spines (fig. 40. up.^{3}).

Telson rounded at the end, with a spine and a seta at each side.

Length 2·5 millims.

The characteristic features of this species are the angular ocular lobes, resembling *Gammaropsis*, the chelate hand of the 1st gnathopods, and the comparative shortness of the last peræopods. It is, however, very possible that the specimen was immature.

Another species of *Lembos* from Cheval Paar has the 1st gnathopods very like

L. websteri. Another from East Cheval Paar appears to be a *Lemboides*, STEBBING, 'Ann. and Mag. Nat. Hist.,' Ser. 6, vol. 16 (1895), p. 209, plates ix. and x., but both are too imperfect for description.

Aora, KRÖYER, 1844.

Aora gracilis (?), SP. BATE.

Pearl oyster washings, Gulf of Manaar.

A very small (2 millims.) and imperfect male from Muttuvaratu had the characteristic gnathopods of this species, and a female, with ova, length 2·5 millims., from East Cheval Paar may possibly belong to it.

Gammaropsis, LILLJEBORG, 1854.

Gammaropsis zeylanicus, n. sp.—Plate VI., figs. 41.

Generally distributed round the coast of Ceylon.

Head as long as the first 2 segments. Ocular lobe produced to more than one-third of the length of the 1st joint of the upper antennæ, subangular; the extremity generally entirely occupied by the eye, which is dark and variable in size and shape.

Hind margin of the 3rd pleon segment rounded. Urosome about as long as the last pleon segment, its 1st segment dorsally depressed.

Upper antennæ more than half as long as the body and longer than the lower, the peduncles subequal; 1st joint twice as thick and two-thirds as long as the 2nd, which is longer than the 3rd; flagellum subequal to the peduncle, with about 14 joints; appendage reaching the middle of the 5th joint of the flagellum, 5-jointed, the last joint the longest.

Lower antennæ: 2nd and 3rd joints subequal, longer than the 11–12-jointed flagellum. Both pairs of antennæ are sparsely setose.

Mouth organs and maxillipeds normal.

First gnathopods (female): side-plates rhomboidal, front not produced, angles rounded; 1st joint subequal to the next 3; wrist subequal to the hand in length and width, very setose on the side and hind margin; hand oval, palm undefined, with setiferous ridges on both margins; dactylus rather long, serrate. In the immature male from the same tube as the female (Station LVIII.) the 1st joint is stronger and has 3 strong curved pectinate setæ at the end of the hind margin; these were not seen on the female or the adult male. In this last the front margin of the side-plates is considerably produced to a rounded acute angle and the 1st joint is very stout, with scattered setæ along the hind margin (fig. 41. gn.[1] ♀).

Second gnathopods (female): side-plates as in the 1st pair, but rather wider; 1st joint strong, the margins subparallel, considerably longer than the next 3 joints; wrist triangular, about half as long as the hand; this is oval, palm only defined by a blunt spine a little beyond the middle of the hind margin, which, as well as that of the

wrist, is very setose; the dactylus reaches a little beyond the spine and is not serrate (fig. 41. gn.[2] ♀).

In the young male the side-plates are oblong, about twice as wide as deep, the angles rounded; 1st joint very stout (width to length as 3 : 5) and longer than the next 3, a number of long setæ on the outer side; wrist short and triangular; hand subovate, margins to the palmar angle subparallel; palm very oblique, uneven, defined by a small blunt tooth, and occupying nearly half of the hind margin, which is setose; the front margin is naked; the dactylus reaches to the palmar tooth and is not serrate (fig. 41. gn.[2] ♂ jr.).

In the adult male the anterior angle of the side-plates is less rounded. The palm of the hand is deeply sculptured with a double tubercle in the middle. The dactylus has an obtuse tooth in the middle of the inner side (fig. 41. gn.[2] ♂ adult).

First and 2nd peræopods: 1st joint rather longer than and twice as wide as the next 2; 3rd joint much longer than the 4th and rather longer than the 5th, which tapers to the base of the dactylus. The whole very sparsely setose.

Third peræopods much shorter than the 4th, the 1st joint wide-oval with smooth margins; 3rd and 4th much wider, but together scarcely longer than the 5th, on which there is a row of spines.

Fourth and 5th peræopods like the 3rd, but longer; the 3rd pair reaches the 4th joint of the 4th pair, and the 4th pair to the same joint of the 5th.

The uropods are subequal in extent, the peduncles of the 1st and 2nd subequal to the rami, with a row of spines on the outer margin; rami also spinous. The 3rd pair have the peduncle considerably longer than the rami, of which the inner is the shorter and pointed with 3 small spines on the outer margin and a terminal spine; the outer has a short spine on the upper side near the middle, with 3 or 4 short and 2 long spines on the tip (fig. 41. up.[3]).

Telson as in *G. erythrophthalmus* (Lillje.).

Length 6 millims.

Cheiriphotis, n. gen.

Body very slender, scarcely compressed laterally; side-plates very small.

Head slightly produced in front, ocular lobes more so, angular or cuspidate.

Upper and lower antennæ subequal, the latter stronger; appendage well developed.

Mandibles with the palp long, 2nd and 3rd joints subequal, the whole as in *Gammaropsis*.

Second gnathopods of moderate size in the female, but immensely developed and peculiarly formed in the male; urus small; the 3rd uropods with the outer ramus very short, without a terminal joint, and the inner rudimentary.

This genus is nearly allied to *Microprotopus*, from which it differs chiefly in the smallness of the side-plates.

Cheiriphotis megacheles (Giles).—Plate VI., figs. 42.

Melita megacheles, Giles (male), 'Journ. Asiatic Soc. Bengal,' 1885, vol. liv., p. 70, pl. iii.

Eurystheus hirsutus, Giles (female), 'Journ. Asiatic Soc. Bengal,' 1887, vol. lv., p. 227, pl. viii.

Rather abundant along the West Coast from Colombo northwards.

Third pleon segment rounded behind; lower margin straight, hind margin convex.

Head not quite as long as the first 2 segments, of which the 1st is the shorter; ocular lobe moderately produced, angular, the angle obtuse and apiculate (fig. 42. o.l.).

Upper antennæ: peduncle subequal to that of the lower; 1st joint shorter and wider than the 2nd, longer than the 3rd; flagellum rather variable in length, generally subequal to the last 2 joints of the peduncle, about 13-jointed. Appendage (in female) reaching the end of the 4th joint of the flagellum, 4-jointed, the first 2 joints together subequal to the 4th. In the males the appendage is 3-jointed, the 1st joint shorter than the 2nd, the 2nd and 3rd subequal; the whole reaching to the end of the 2nd joint of the flagellum; the appendage has, in addition, a minute terminal joint in both sexes.

Lower antennæ rather stronger than the upper, the 1st joint about one-third of the 2nd; 2nd, 3rd, and flagellum subequal, the last 9-jointed. Both pairs of antennæ are rather thinly clothed on the under side with long setæ.

Mouth organs as in *Gammaropsis*, except the inner plate of the 1st maxillæ, which is round-oval, with 4 setules on one side.

Maxillipeds as in *Gammaropsis*.

First gnathopods: side-plates acutely produced in front and fringed round the blunt point and below with long setæ, especially in the female. The 1st joint is as long as the wrist, which is longer than the hand and has the hind margin rather flattened and very setose; the hind margin of the hand is evenly convex, with no definite palm, and is setose on the middle part. Dactylus about half as long as the hind margin, with a row of setules on the inner margin (fig. 42. $gn.^1$).

Second gnathopods (female): Side-plates small subquadrate, angles rounded, lower margin fringed with long setæ. First joint very strong, subequal to the hand, with long setæ on the front margin; wrist half as long as the hand, triangular, produced and setose behind; hand subovate, palm oblique, uneven, defined by a strong tooth just below the point of the dactylus (fig. 42. $gn.^2$ ♀).

The young male has the hand much wider than the female, though less so than the adult male; the palm is somewhat obliquely transverse, defined by a strong pointed tooth; near the middle is a double pointed tooth and a single one near the base of the dactylus; the latter is wider in the middle than in the adults. The wrist is produced towards the *front* margin of the hand and cannot be seen behind (fig. 42. $gn.^2$ ♂ jr.).

In the adult male the 1st joint is shorter, the width being three-fourths of the length, which is subequal to the next 2 joints. The wrist has disappeared or can only be seen in a reduced form through the wall of the 3rd joint. The hand is

subquadrate, as long and wide as the first 3 segments united; the proximal part of the front margin is very convex and fringed with long plumose setæ; the palm is rectangularly transverse, defined by a sharp tooth with 5 equidistant, irregular teeth between it and the hinge of the dactylus. The hind margin is almost straight and about two-thirds as long as the front, with a few setæ below the palmar angle. Dactylus slightly curved, narrow, with subparallel margins, the point meeting that of the defining tooth (fig. 42. gn.^{2} ♂). Dr. GILES' specimen had only 3 teeth on the palm, but this is a feature that doubtless varies with age.

First peræopods rather longer than the first 3 joints of the 2nd gnathopods in the male, and as long as the whole limb in the female; 1st joint curved in the male, straight in the female, rather stout; 3rd and 5th subequal in length, the 3rd widened distally with a group of long stiff setæ at the anterior angle. Dactylus rather slender and recurved (fig. 42. pp.^{1}). In the female this limb is much more setose than in the male.

Second peræopods in the female like the 1st pair; in the male smaller and with the 1st joint straight.

Third peræopods about as long as the 2nd pair in the male: 1st joint much expanded behind and fringed on both margins; next 3 joints subequal in length and width; 5th longer and narrower, with 5 or 6 spines on the hind margin. All the joints have long plumose setæ on the front margin and the 3rd and 4th joints have a group at the posterior angle as long as the next joint. Dactylus rather short, recurved, and reversed as in *Photis* (fig. 42. pp.^{3} ♂).

The remaining peræopods increase in length successively, the last pair extending beyond the uropods and having the 1st joint broader than the 4th pair. Both pairs are densely hirsute.

The first uropods extend a little beyond the 2nd, and these beyond the 3rd; in the 1st and 2nd the rami are subequal and shorter than the peduncles, all the parts being spinous.

The 3rd uropods have the outer ramus shorter than the peduncle, without a terminal joint, but with 3 short spines and some stiff setæ at the tip; inner ramus a spiniferous tubercle (fig. 42. up.^{3}).

Telson as in *Microprotopus*, squarely truncate when seen from above mounted, with 3 or 4 setæ in each angle; it does not quite reach the end of the peduncle of the 3rd uropods.

Length of male, 4 millims.

Incubatory lamellæ elongate-triangular, the apex below.

The great size and resemblance in shape and colour to a broken piece of shell in the hands of the 2nd gnathopods of the male suggest, as in *Melita anisochir*, KR., a protective purpose. It is, however, not easy to see why, in both species, the males only should be protected. There can, I think, be little doubt that *Eurystheus hirsutus*, GILES (*loc. cit.*), is the female of this species.

Photis, Kröyer, 1842.

Photis longicaudata (Sp. Bate).—Plate VI., figs. 43.

West Coast of Ceylon, from Galle northwards; generally abundant.

Length of female with ova, 3·5 millims.

I have referred the specimens examined to the above species chiefly on account of the prominence of the ocular lobe (fig. 43. c.). In other respects it is equally near the other two species described by G. O. Sars, the limbs in some specimens being as robust and hairy as in *P. reinhardi*, Kr., while the hand of the 2nd gnathopods resembles that of *P. tenuicornis* (fig. 43. gn.^{2}). It is a question whether these 3 species and *P. pollex*, A. O. Walker, ought not to be merged in the oldest recorded form, *P. reinhardi*. The Ceylon specimens are remarkably variable. The colour in spirit is dark yellowish-green spotted with black or brown.

One of the forms has the hind margin of the outer ramus of the last 2 pairs of pleopods expanded near the base and furnished with peculiar longitudinally-striated, tapering plumose setæ radiating symmetrically from the curved margin (fig. 43. plp.). In this form the side-plates and gnathopods are setose.

Photis longimanus, n. sp.—Plate VII., figs. 44.

From pearl oysters, East Cheval Paar, 8th November, 1902; 5 specimens.

Male.—Head about as long as the first two segments.

Ocular lobe reaching almost to the end of the 1st joint of the lower antennæ. Eye large, occupying almost the whole lobe, dark.

Hind angle of the 3rd pleon segment rounded.

Upper and lower antennæ subequal, scarcely reaching to the pleon, sparsely setose; 1st joint of the upper twice as thick as, but shorter than, the 2nd, and subequal to the 3rd; flagellum 6-jointed, subequal to the 2nd and 3rd joints of the peduncle together.

First joint of the lower antennæ about half as long as the second, which is subequal to the 3rd; flagellum 6-jointed, rather shorter than the last 2 joints of the peduncle.

Mouth organs and maxillipeds normal.

First gnathopods: side-plates oblong, much wider than deep, angles rounded; 1st joint as long as the 3rd and 4th and at least as wide as the hand; wrist as wide as, and considerably longer than, the hand, which is oval; the palm undefined (fig. 44. gn.^{1}).

Second gnathopods: side-plates small, rounded-oblong; the first 4 joints very short and stout. *Wrist brought round the base of the hand on the outside and produced beyond it in an oval lobe.* Hand long, narrowing distally, a strong blunt tooth near the base on the *inner* surface, the hind margin divided into 3 nearly equal concave spaces by this and 2 other teeth, the middle one being the smallest. Dactylus strong, reaching the basal tooth (fig. 44. gn.^{2} ♂).

The peræopods do not differ materially from those of *P. reinhardi*, Kr., except in being less setose; the last pair extends to the end of the 3rd uropods.

The segments of the urus decrease successively in length; the 1st has a dorsal depression.

The uropods are subequal in extent, short and stout; the outer rami in the 1st and 2nd rather shorter than the inner and about half as long as the peduncles, without terminal spines or setæ. The 3rd pair has the inner ramus almost rudimentary, the outer curved, rather longer than the peduncle, with a minute terminal joint and 1 or 2 slender spines on it. With the exception of 2 or 3 setules on the telson, the urus appears to be entirely destitute of setæ.

Telson not quite reaching the end of the peduncle, of the usual form.

Length 3 millims.

Colour in spirit yellowish, with a few dark-red blotches on the body and limbs. No female was observed. The species may be distinguished by the peculiar form of the wrist and hand of the 2nd gnathopods.

Photis nana, n. sp.—Plate VII., figs. 45.

Pearl oyster washings, Muttuvaratu, 19th Nov., 1902. Two females with ova.

Head longer than the first 2 segments. Ocular lobe distinct, but not prominent. Eye round, rather small.

Posterior angle of the 3rd pleon segment rounded.

Antennæ subequal in length and width, except the 1st joint of the upper, which is at least twice as wide as any of the other peduncular joints; both pairs are almost naked. In the upper pair the 3 joints of the peduncle are subequal in length, the 1st with a group of setæ at the distal end; the flagellum about as long as the last 2 joints of the peduncle, with 3 rather long subequal joints and a minute terminal one which, as well as the 2 preceding, has one or two strap-shaped setæ at the end. The lower antennæ have the 1st joint very short; the 2nd shorter than the 3rd; the flagellum as long as the peduncle.

First gnathopods: 1st joint curved, as long as the next 3; wrist about two-thirds as long as, but wider than, the hand, with a group of setæ on the convex hind margin. The hand narrows distally to the base of the dactylus, the distal half of the hind margin setose (fig. 45. gn.[1]).

Dactylus with a spine and 2 setules on the inner margin, which is finely pectinate.

The 2nd gnathopods resemble the 1st in size and form, but the 1st joint is less curved and the 3rd has the end of the hind margin squarely truncate (fig. 45. gn.[2]).

First and 2nd peræopods: 1st joint pyriform, longer than the next 3, the hind margin convex and setose at the distal end (fig. 45. pp.[1]).

Third peræopods as in *P. reinhardi*, but without setæ, except one at the end of the hind margin of the 4th joint and one at the base of the dactylus.

Fourth and 5th peræopods as in *P. reinhardi*, except the 1st joint, which is more oblique and the whole less setose.

The uropods are without spines or setæ, except at the ends of the joints. The 3rd

pair extends slightly beyond the 2nd; the inner ramus very small, the outer almost as long as the peduncle, curved, with a minute terminal joint, no spines or setæ (fig. 45. up.[3]). Telson obtusely pointed.

Length 2 millims.

The peculiar gnathopods of this small species seem to indicate that a new genus will be required for it when the male is found.

Chevalia, n. gen.

Body laterally compressed.

Head without a rostrum.

Antennæ subequal, the upper with an appendage.

Mandibles small; palp long and slender, 3-jointed.

First and 2nd maxillæ as in *Cerapus*, but relatively smaller.

Palp of the maxillipeds with the last joint blunt.

First gnathopods slender, as in *Gammaropsis.*

Second gnathopods with large wrist and hand alike in both sexes.

The last 3 pairs of peræopods with the dactyli inverted, as in *Cerapus.*

First and 2nd uropods with dissimilar rami; 3rd with 2 well-developed rami.

Telson, as in the Photidæ.

This curious genus is intermediate between the Photidæ and the Corophiidæ. It resembles the former in the form of the body, head, antennæ, gnathopods, and telson; and the latter in the inverted peræopods and the dissimilar rami of the 1st and 2nd uropods, though in the new genus the dissimilarity is greater. Notwithstanding these points and the similarity of the 2nd gnathopods in the males and females, I have placed this form under the Photidæ as the family with which it has the greatest affinity.

Chevalia aviculæ, n. sp.—Plate VII., figs. 50, and Plate VIII., fig. 50).

Pearl oyster washings, East Cheval and Muttuvaratu paars: about 20 specimens

Body smooth, without dorsal spines or teeth; much curved; speckled with red.

Head as long as the first 2 segments; ocular lobe subangular, not very prominent.

Eyes oval—colourless in spirit.

Segments of the mesosome increasing in length successively, the 7th twice as long as the 1st.

Pleon segments with a pair of upright setæ on their postero-dorsal margins; the epimere of the 3rd rounded behind and below.

First 2 segments of the urus coalesced and subequal to the last pleon segment; 3rd segment about half as long.

Antennæ about two-thirds of the length of the body, subequal in the female; the upper rather the longer in the male; in the upper the 1st and 2nd joints are subequal, about one-third longer than the 3rd; flagellum 7-jointed; appendage 1-jointed, as long as the 1st joint of the flagellum.

Lower antennæ: 1st joint about half as long as the 2nd, which is rather longer than the 3rd; flagellum 6-jointed, subequal to the last 2 peduncular joints. Both pairs are similarly fringed below with long curved setæ.

Mandibles small, shorter than the 2nd joint of the palp; cutting edge double; molar tubercle rather large, but not prominent, palp projecting to the middle of the 2nd joint of the lower antennæ; 1st joint very small, 2nd and 3rd subequal (fig. 50. m.).

Maxillipeds: inner plate reaching the end of the 1st joint of the palp, spinous on the angle: outer narrow, reaching the middle of the 2nd joint, with slender curved spines near the top: 1st and 3rd joints of palp subequal; 2nd about twice as long; 4th rather more than half as long as the 3rd, the apex rounded and setose.

First gnathopods: side-plates small, front angle acute, with a setule on the point; 1st joint subequal to the wrist, curved; wrist subequal to the hand in length and width, the hind margin setose; hind margin of the hand convex and setose, the palm undefined. Dactylus half as long as the hind margin (fig. 50. gn.¹).

Second gnathopods: side-plates as in the 1st, but smaller; 1st joint stout, subequal to the next 3; wrist subequal in width to the hand, along the anterior margin of which it is carried for about one-third of its length. Hand longer than the wrist, subquadrate, the palm almost rectangular to the hind margin, convex, and defined by a strong tooth, behind which is a notch which receives the point of the dactylus (fig. 50. gn.²).

First and 2nd peræopods are rather longer than the 2nd gnathopods and strongly built; the side-plates alike small and triangular, the angles rounded. The 1st joint is subequal to the next 3, about twice as wide as the 3rd joint, and widening distally; the front margin distally convex in the 1st pair and straight in the 2nd; the 3rd joint as long as the 2nd, 4th, and 5th together, and twice as wide as the last 2. Dactylus short (fig. 50. pp.²).

Third peræopods hardly reaching the end of the 1st joint of the 2nd pair; 1st joint almost as wide as long, the front margin very convex; the 2nd subequal to the 4th and the 3rd to the 5th, which is the narrowest; the 3rd and 4th are obcordate. Dactylus reversed, with a secondary tooth on the outer side (fig. 50. pp.³).

Fourth peræopods like the 3rd, but longer.

Fifth peræopods rather longer than the 4th; the 1st joint with the hind margin almost straight and ending in a rounded right angle; otherwise as in the preceding pairs (fig. 50. pp.⁵).

The last 3 pairs of peræopods are feeble, the last pair hardly reaching the 3rd pleon segment, and neither as long or strong as the first 2 pairs of peræopods; they are almost devoid of spines or setæ.

First uropods: peduncle rather shorter than the upper ramus, which is styliform, curved and spinulous on the proximal half of the inner margin; the lower ramus is about one-fourth shorter than the upper, obliquely truncate at the end, where there

is a crowded group of short blunt spines; the inner margin has a row of microscopic ciliæ (fig. 50. up.[1]).

Second uropods of similar structure to the 1st, but shorter in extent.

It is very difficult to determine which is the "inner" or the "outer" ramus, as, in fact, the one lies immediately above the other in these 2 pairs.

Third uropods: peduncle subequal to the inner ramus, which is rather longer than the outer; both are alike and simple, with obliquely truncate setose ends (fig. 50. up.[3]).

Telson as in *Gammaropsis.*

Length of ovigerous female 4 millims.

Probably a tubicolous species, from the structure of the last 3 pairs of legs. So far it has only been obtained from the washings of pearl oysters.

Amphithoë, Leach, 1813.

Amphithoë intermedia, n. sp.—Plate VII., figs. 46.

West Coast of Ceylon, from Colombo northwards.

Head shorter than the first 2 segments. Ocular lobe slightly produced, subangular. Eye round, red.

Third pleon segment: lower and hind margins convex, angles rounded.

Upper antennæ: 1st joint stout, almost as long as the slender 2nd; the 3rd barely one-third of the 2nd; flagellum slender, 30-jointed.

Lower antennæ: 1st joint very short, 2nd and 3rd subequal, but the 2nd the wider; *flagellum subequal to the last joint of the peduncle, 9-jointed.*

Mandibles normal, the palp scarcely as long as the mandible; 1st joint about half as long as the 2nd, which is subequal to the 3rd; this widens distally and is obliquely truncate, with 7 pectinate setæ on the truncate part and 1 below (fig. 46. m.).

First maxillæ: inner plate with 3 setæ (fig. 46. mx.[1]).

Remaining mouth organs and maxillipeds normal.

First gnathopods in the female as in *A. rubricata* (Mont.), the side-plates rather wider below, with a few setæ on the rounded posterior angle. In the male the whole limb is more robust; the hind margin of the wrist straight, crenate, setose, and ending in an acute angle; the hand scarcely as wide as the wrist, oblong; the dactylus strong and serrate (figs. 46. gn.[1] ♀ and ♂).

Second gnathopods in the female very like and but little larger than the 1st; the side-plates oblong, with setæ as in the 1st; the wrist is produced behind in a truncate lobe which is densely setose; the hand is about half as long again as the wrist, *the palm slightly convex, defined by a spine, but rounded off into the hind margin,* which is rather the longer; the whole hind margin setose. Dactylus reaching a little beyond the palmar spine, serrate (fig. 46. gn.[2] ♀).

In the male the side-plates are suborbicular, the diameter less than the length of the 1st joint, which is subequal to the next two; the front margin of the wrist is

about half as long as that of the hand, and has a few unequal spines near its proximal end; the hind margin is a small, rounded, setose lobe. The hand has its anterior surface furnished with numerous setiferous ridges, the setæ very long; this part is produced in a rounded lobe beyond the base of the dactylus. The hind margin is subparallel with the front for about half its length, where it forms a strong tooth* which forms a deep V-shaped sinus with the palm. The point of the dactylus just meets that of the tooth (fig. 46. gn.[2] ♂).

The peræopods resemble those of *A. rubricata*, but are rather more slender.

The 1st and 2nd uropods have their outer rami subequal to the peduncles, the inner rather longer; all the parts are spinous.

The 3rd uropods have the inner ramus slightly longer than and subequal in width to the outer, the end rounded with a group of unequal spines at the end and 4 along the inner margin; the outer as in *A. rubricata*.

Telson as in *A. rubricata*.

Length of female with ova, 4 millims.

This species appears to connect *A. rubricata* with *A. vaillanti*, Lucas; the female agreeing with the former, but differing from the latter in the hand of the 2nd gnathopods, while the reverse is the case in the male. The form described by Della Valle as *A. rubricata* is, as pointed out by Chevreux ('Amphipodes des campagnes de "l'Hirondelle,"' 1885–8, p. 100,† who also gives the synonomy of that species), *A. vaillanti*.

The incubatory lamellæ of the 2nd gnathopods are narrow; the branchial pyriform broader at the lower end than in *A. rubricata*.

Amphithoë vaillanti, Lucas.

Station LVIII., two females with ova; length 6 millims.

Ischyrocerus, Kröyer, 1838.

Ischyrocerus anguipes, Kr. (?).

Coast of Ceylon, under 100 fathoms, exact locality not known.

One male and 1 female with ova; length 2·5 millims.

I should not hesitate to refer these specimens to Kröyer's species were it not for the entire absence of their antennæ, their very small size (neither of these characters being, however, of much importance in this genus), and the fact that the species has not been recorded south of the Kattegat. The shape of the hand of the 2nd gnathopods in the male agrees exactly with Sars' figure of *I. anguipes*, differing in the concave hind margin from its nearest and more southern ally, *I. minutus*, Lilljeborg. With the latter species I am well acquainted, having formerly described it under the name of *Podocerus isopus*.

* In a male from Station LVI. (tube 43) this tooth becomes a lobe.

† "Résultats des Campagnes scientifiques du Prince de Monaco," 1900.

Jassa, Leach, 1813 (= Podocerus, Auct.).

Jassa falcata (Montagu) (?).—Plate VII., fig. 47.

Muttuvaratu Paar, 19th November, 1902. One female without ova; length 4 millims.

In the absence of a male it is impossible to be sure of the species, but in its principal features this agrees with the above. The limbs and antennæ are more robust; the flagellum of the upper antenna is 6-jointed, about as long and half as wide as the last joint of the peduncle, the 1st joint as long as the next 3; appendage 1-jointed, about one-third of the 1st joint of the flagellum. The terminal joint of the palp of the maxillipeds is oblong, not pointed. The 2nd gnathopods are very robust, but of much the same form as in *J. falcata*. The 1st joint is about half as long as the hand; the separation of the 2nd and 3rd joints is not very distinct, and the wrist appears to be entirely coalesced with the hand. The dactylus is apparently encased in a sort of sheath to within a short distance of the point, the lower margin being studded with minute equidistant denticles.

Erichthonius, Milne Edwards, 1830.

Erichthonius abditus (Templeton).

Abundant from a basket hung to a buoy in Galle Harbour, 9th May, 1902; also from other localities along the coast.

Length of female with ova, 7 millims.

Erichthonius macrodactylus (Dana). -Plate VII., figs. 48.

Pyctilus macrodactylus, Dana, 'U.S. Exploring Exp.,' p. 974, plate 67.

Station LIII., north part of Gulf of Manaar; a few specimens.

Head as long as the first 2 segments, of which the 1st is very short, the remainder subequal. Ocular lobe moderately produced. Eye medium sized, dark, roundish-oval.

Upper antennæ reaching the middle of the flagellum of the lower; the 1st joint little more than half the length of the 2nd, which is rather longer than the 3rd; flagellum 13-jointed, subequal to the last 2 joints of the peduncle.

Lower antennæ: peduncle longer than that of the upper, the 2nd joint shorter than the 3rd, a red blotch upon both; flagellum rather longer than these two together.

Mouth organs normal except the palp of the mandible, which, both in this species and in *E. abditus*, differs from the European form of the latter in having the 3rd joint rather narrower than the 2nd and less expanded towards the tip (fig. 48. m.).

Maxillipeds normal.

First gnathopods as in *E. abditus*.

Second gnathopods as in *E. abditus* in the female. In the male it is very near to *E. difformis*, M. Edw., *but the thumb-like process of the wrist has the outer margin*

quite straight, while the inner is parallel to the outer for half its length, and thence tapers to a very sharp point, with a tuft of setæ on the outer margin; the distal half of the proper hind margin of the wrist is quite straight. The hand is narrow and curved, *the margins parallel without any prominence on the inner.* Dactylus fully as long as the hand (fig. 48. gn.^{2} ♂).

First and 2nd peræopods as in *E. abditus*.

Third peræopods: in the male the 1st joint has the hind margin produced downwards in a narrow rounded (not "acute," as described by DANA, though figured rounded) lobe reaching beyond the end of the 2nd joint; the 3rd joint is longer than the next 3, curved and expanded at the end (fig. 48. pp.^{3} ♂). In the female the 1st joint is without the lobe, and the 3rd joint is straight and shorter than the next two.

The 4th pair are slender and much longer than the 3rd, the 3rd and 5th joints subequal.

The 5th pair are longer than the 4th and extend considerably beyond the uropods; *the 5th joint is as long as the 3rd and 4th together.*

First uropods: peduncle considerably longer than the rami, the inner margin with 5 or 6 spines, rounded off and pectinate or finely serrate at the end; inner ramus a little shorter than the outer, both spinous and minutely pectinate.

Second uropods like the 1st, except the inner margin of the peduncle, which is not rounded or pectinate on the inner margin.

Third uropods as in *E. abditus*—two unequal spines near the middle of the outer margin and a small one near the base of the peduncle.

Telson as in *E. difformis*, with an obtuse central tooth.

Length 5 millims.

The colour of the specimens (in spirit) was lighter than in *E. abditus*, with dull red blotches and transverse bars on the body and limbs. This species may be considered as the eastern form of *E. difformis*, from which the male differs in the even hind margin of the hand, the somewhat differently formed wrist of the 2nd gnathopods, and, still more, in the peculiar construction of the 3rd peræopods. The female can only be distinguished from *E. abditus* by its greater slenderness generally, and especially by the great length of the 5th joint of the last peræopods.

Cerapus, SAY, 1817.

Cerapus calamicola (GILES).

Cyrtophium calamicola, GILES, 'Journ. Asiatic Soc. Bengal,' vol. liv., 1885, p. 54, pl. ii. ♂.

Cerapus flindersi, STEBBING, '"Chall." Amph.,' p. 1163, plate cxxv. ♀.

Cerapus flindersi, STEB., CHILTON, 'Rec. Aust. Mus.,' vol. ii., p. 1 (separate copy), pl. 1. ♂.

Station LIII., Periya Paar Kerrai, many, with tubes. East Cheval Paar.

A female from Station LIII. measured 6 millims.; those from Periya Paar Kerrai only 3 millims.

Siphonœcetes, Kröyer, 1845.

Siphonœcetes orientalis, n. sp.- Plate VII., figs. 49.

Station V., several; Station LIII., two; and Station LVIII., two specimens.

Rostrum acute deflexed, as long as the ocular lobes, which are almost rectangular, narrowing distally. Eyes small but distinct, with about 6 lenses.

First 4 side-plates acutely angled and fringed with rather long setæ.

Upper antennæ reaching beyond the middle of the 3rd joint of the peduncle of the lower, the 1st and 3rd joints equal; flagellum shorter than the peduncle, 14-jointed.

Lower antennæ almost as long as the whole body, the 1st joint about half as long as the 2nd, which is a little longer than the 3rd; flagellum about half as long as the last joint of the peduncle, 3-jointed, the 2nd one-fourth as long as the 1st, the 3rd minute. The whole of the flagellum is armed with a row of 5 or 6 strong recurved spines on each margin of the lower side. The lower side of the 2nd joint of the peduncle is sparsely, and that of the 3rd densely, clothed with long plumose setæ (fig. 49. ant.^{2}).

First gnathopods: 1st joint, hand, and wrist subequal, the hand throughout narrower than the wrist, and narrowing gradually from the base to the end with 4 spines on the hind margin; both hand and wrist setose on both margins. Dactylus with a row of spines on the inner margin, increasing in size distally (fig. 49. gn.^{1}).

Second gnathopods: much as in *S. colletti*, Boeck, but the hand narrower, the widest part near the base, from which point to the dactylus the hind margin is slightly concave, with 5 spines increasing in size distally (fig. 49. gn.^{2}). Dactylus as in the 1st gnathopods.

The rest as in *S. colletti.*

Length 5 millims.

The narrowness of the hands of the gnathopods distinguishes this species from the others, but I confess that I am inclined to agree with Della Valle (*loc. cit.*, p. 362), that the points of difference between *S. typicus*, Kröyer, the original Arctic species, *S. colletti*, Boeck, and *S. pallidus*, Sars, are not greater than can be accounted for by age, &c., so that both these species, as well as the present one, might well be united to *S. typicus.*

Corophium, Latreille, 1807.

Corophium crassicorne, Bruzelius.

Periya Paar Kerrai, 9th November, 1902. Two males, one female.

Length 2·5 millims.

The only difference observed between this and the European form was that there are 2 spines on the 3rd joint of the lower antennæ in the female instead of one.

Platophium, Dana, 1852.

Platophium læve (Haswell).—Plate VII., figs. 51.

Dexiocerella lævis, Haswell, 'Proc. Linn. Soc., N.S. Wales,' vol. x., 1886, p. 111, pl. xviii.
Cyrtophium haswelli, Chevreux and De Guerne, 1888.

Stations V., XLVII., LVIII., all in Gulf of Manaar.

The first 5 segments of the mesosome with a median transverse depression, the last segment and the first 2 of the pleon carinate, the carinæ not produced behind.

Head considerably longer than the 1st segment. Lower angle of the ocular lobe bluntly rectangular. Eyes wide-oval, dark in the centre.

Upper antennæ about as long as the head and first 2 segments; 2nd and 3rd joints of peduncle subequal, the flagellum the same length, 4-jointed in the females, 5-jointed in the males, the 1st joint much the longest. Appendage about one-third of the 1st joint. The whole setose below.

Lower antennæ are longer and less setose in the male than in the female, the 2nd joint considerably shorter than the 3rd and subequal to the 3-jointed flagellum.

First gnathopods: side-plates rhomboidal; 1st joint rather shorter than the next 3; hind margin of the wrist almost straight, setose. Hand subtriangular, longer than the wrist in the male, widest near the base, the palm occupying two-thirds of the hind margin and defined by a group of spines. Dactylus barely reaching the palmar spines; a row of spines on the inner margin and an obscure denticulation on the outer near the point, which has a secondary tooth, giving it a split appearance. In the female the hand is proportionately shorter than in the male, being only about as long as the wrist (figs. 51. gn.^{1}).

Second gnathopods, female (fig. 51. gn.^{2} ♀): the whole limb short and stout; the 1st joint subequal to the next 3; 3rd joint produced behind to a point tipped with a spine; wrist triangular, cup-shaped, with spines round the margin, about one-third as long as the hand; this is widely oval, the palm about 3 times as long as the rest of the hind margin, from which it is defined by a spine; about 6 spines and 4 long setæ on the palmar edge, and 4 marginal and 3 submarginal spines on the front margin; dactylus rather longer than the palm. In the male the hand is 4 times as long as the wrist, about 3 times as long as the hand in the female and proportionately narrower; the palm occupies nearly the whole of the hind margin, is defined by a small tooth, and is spinous, with a few short setæ throughout its length; there are 5 groups of spines (1 long and 2 short spines in each) along the front margin (figs. 51. gn.^{2}).

First and 2nd peræopods: the 1st joint narrow and as long as the next 2; the 3rd joint expanded distally, the front margin subangulate; 5th joint almost as long as the 3rd and 4th; all the joints spinous (fig. 51. pp.^{1}).

Third peræopods: 1st joint with a projecting lamina behind narrowing distally; 3rd and 4th joints subequal, 5th nearly twice as long; dactylus strong (fig. 51. pp.^{3}).

Fourth and 5th peræopods like the 3rd, except the 1st joint, which is wider and rounded behind.

The outer rami of the 1st and 2nd uropods are shorter than the inner and are terminated by a long spine, as also the inner ramus of the 2nd pair; the inner ramus of the 1st pair has 3 shorter and unequal spines and the inner margin finely pectinate and spinulose (fig. 51. ur.).

The 3rd uropods are uni-ramous, oval, acuminate, with a setule at the tip, about two-thirds covered by the telson (fig. 51. up.[3]).

The telson seen in profile is triangular, with 2 spines on the summit and the margin of the extended base upturned (fig. 51. t.).

Length of female with ova, 3·5 millims., but the females appear to become sexually mature very young in this genus, as much smaller females are full of ova.

In 1888, CHEVREUX and DE GUERNE referred HASWELL'S genus *Dexiocerella* to *Cyrtophium*, DANA, and as the specific name *læve* was preoccupied by *C. læve*, HELLER, they re-named HASWELL'S species *C. haswelli*. As, however, the species belongs to *Platophium*, I have reverted to HASWELL'S name, HELLER'S species having no antennular appendage.

It is possible that this species is identical with *Cyrtophium orientale*, DANA, in which, however, no antennular appendage is figured or described.

Platophium synaptochir,* n. sp.—Plate VIII., figs. 52.

Galle Harbour and Bay, very abundant. Kondatchi Paar, Periya Paar Kerrai, East Cheval Paar. All taken from May to November, 1902.

Male:—The first 4 segments of the mesosome are subequal, the 5th rather shorter, the 6th longer; the 7th the longest; all, as well as the pleon segments, have a transverse dorsal depression, and are elevated behind, but not carinate or produced behind. Urus with 3 distinct segments. Head longer than the 1st segment; ocular lobe subangular. Eye large, round, dark red.

Upper antennæ reaching to one-third of the last joint of the peduncle of the lower; the 1st joint twice as thick and more than half as long as the 2nd, which is about one-fourth longer than the 3rd. Flagellum as long as the 3rd joint, 5-jointed, the 1st joint as long as the remaining 4. Appendage 1-jointed, nearly half as long as the 1st joint of the flagellum; the whole rather sparsely clothed below with long, simple setæ.

Lower antennæ as long as the mesosome; the 1st joint less than half as long as the 2nd, which is much shorter than the 3rd. Flagellum shorter than the 2nd joint, 4-jointed, the 1st longer than the remaining 3; the whole sparsely furnished with short setæ.

* From συνάπτω, to join, and χειρ, hand, in allusion to the coalescence of the hand and wrist in the 2nd gnathopods of the male.

Palp of the 1st maxillæ with the 2nd joint not wider than the 1st and not expanding distally (fig. 52. mx.[1]).

Other mouth organs as in *P. inconspicuum*, STEB. ('Chall. Amph.,' p. 1194, pl. cxxxi.).

First gnathopods: side-plates small, produced to a blunt point with a setule. First joint short and stout, longer than the next 2; wrist shorter than the hand, but fully as wide, the front margin with curved spines, the hind margin flattened and densely setose; the hand has the hind margin concave near the base, with a straight and very setose palm; the front margin convex (fig. 52. gn.[1] ♂).

Second gnathopods of male: side-plates oblong, wider than deep, rounded in front. First joint about half as long as the hand, 3rd joint convex and setose, with the hind margin produced distally. Wrist merged in the hand, which is narrow-oval, with the hind margin slightly concave and densely setose; the palm is undefined. The front is convex, with groups of spines. Dactylus reaching rather beyond the middle of the hind margin (fig. 52. gn.[2] ♂).

The gnathopods in the female much resemble those of *P. inconspicuum*, STEB., but the wrist of the 1st pair is as wide as the hand, and the point of the dactylus is not divided as in that species. In the 2nd pair the 3rd joint is more produced behind, and the wrist, which is quite distinct, though small, is not produced at all (fig. 52. gn.[2] ♀).

First and 2nd peræopods: first joint narrow and subequal to the 4th, with long spines on the front margin: the 5th the longest, its hind margin, with 5 spines, increasing in length distally (fig. 52. pp.[1]).

Third peræopods: side-plates bilobed, the front lobe the larger. First joint with the lamina projecting beyond the proximal part of the hind margin, the distal part fringed with slender, unequal spines; 3rd joint acutely produced behind; 5th joint rather shorter than the 3rd and 4th together; the whole limb spinous (fig. 52. pp.[3]).

Fourth and 5th peræopods resembling the 3rd, except in the 1st joint, in which the posterior lamina is continuous along the hind margin (fig. 52. pp.[5]).

Uropods: the outer ramus of the 1st as long as the inner of the 2nd, the peduncles shorter than the inner rami; the whole spinous (fig. 52. ur.).

The 3rd pair small and spoon-shaped, with a setule on the inner margin, barely reaching beyond the end of the telson.

Telson as in the last species, but with 2 groups of 3 or 4 spines on each side.

Length of adult male, 6·5 millims. Female, with ova, 3·5 millims.

Platophium zeylanicum, n. sp.—Plate VIII., figs. 53.

From pearl oysters, East Cheval Paar, November, 1902; several.

Segments of mesosome and pleon dorsally depressed in the middle, not carinate or dentate. Urus with 3 segments, the division between the 2nd and 3rd somewhat indistinct. Head shorter than the first 2 segments. Ocular lobe little produced. Eyes round and prominent.

Upper antennæ: the 1st joint half as long and twice as wide as the 2nd, which is equal to the 3rd; flagellum subequal to the 3rd joint, 3–4-jointed, the 1st as long as or longer than the remainder; appendage about half as long as the 1st joint of the flagellum, 1-jointed (fig. 53. ant.[1]).

Lower antennæ: the 1st joint sub-globose, more than twice as wide as the 2nd, which is considerably shorter than the 3rd and subequal to the flagellum; this is 3–4-jointed.

First gnathopods: side-plates much produced in an acute angle, with a seta at the tip; the rest of the limb much like the last species (fig. 53. gn.[1] ♂).

Second gnathopods of female: side-plates small, subquadrate, with rounded angles. First joint rather shorter than the hand; 3rd more than twice as long as the 2nd, and produced beyond the wrist as in the last species; wrist small and triangular; hand wide-oval, both margins convex, especially the front, and setose; palm hardly defined, but a spine within the point of the dactylus, which is slender; the setæ are stiff and spine-like. Incubatory lamellæ very large, sub-oblong, the upper part spotted with red (fig. 53. gn.[2] ♀).

Second gnathopods of male: 1st joint expanded distally, longer than the next 3, with a channel in front to receive the hand; 3rd joint twice as long as the 2nd, the hind margin rectangular; the wrist very small and almost concealed by the 3rd joint; hand much longer than all the preceding joints united, oval, a strong tooth near the middle of the hind margin defining the palm, between which and the base of the dactylus are two tubercles with concave interspaces, the whole clothed with unequal plumose setæ. Dactylus barely reaching the palmar tooth, with a row of denticles on the inner margin. The sculpturing of the palm is somewhat variable (fig. 53. gn.[2] ♂).

First and 2nd peræopods: the 1st joint subequal to the 4th joint, with a laminar expansion of the front margin which is rounded and furnished with a group of stiff setæ; 3rd joint shorter than the 4th, produced and spinous in front; 5th joint almost as long as the 3rd and 4th united (fig. 53. pp.[1]).

Third peræopods: 1st joint shorter than the 4th, with a semicircular membranous expansion behind (fig. 53. pp.[3]); the rest as in the preceding pairs.

Fourth and 5th peræopods: 1st joint wider above, but otherwise like the 3rd pair: the 5th pair reaches far beyond the ends of the uropods (fig. 53. pp.[5]).

First uropods: peduncle subequal to the outer ramus, reaching beyond the telson; inner ramus about one-fourth longer and wider (fig. 53. ur.).

Second uropods shorter in extent than the 1st; peduncle reaching to the end of the telson, shorter than the outer ramus, which is one-third shorter than the inner. In both pairs the rami are spinous, the terminal spines about one-fourth of their length.

Third uropods not reaching beyond the end of the telson.

The telson has the form of a truncated cone, the apex directed backwards, with a long terminal and 2 shorter subterminal spines (fig. 53. t.).

Length of male, 4 millims.; of female, with ova, 2·5 millims.

The males of this species may be distinguished by the 2nd gnathopods; the females in the genus *Platophium* are very much alike, but in this case may be known by the triangular expansion of the 1st joint of the 1st and 2nd peræopods.

Colomastix, Grube, 1861.

Colomastix pusilla, Grube.

Cratippus tenuipes, Sp. Bate.

Exunguia stilipes, Norman.

Pearl oyster washings, Muttuvaratu Paar—2 specimens.

EXPLANATION OF PLATES.

List of Abbreviations used with the Figures.

c. and *ceph.* = cephalon, head.
o.l. = ocular lobe.
ant^1., *ant*^{2}. = upper and lower (1st and 2nd) antennæ.
m. = mandible.
mp. = mandibular palp.
mx^1. = 1st maxillæ.
l. = posterior lip.
mxp. = maxillipeds.
gn^1., *gn*^{2}. = 1st and 2nd gnathopods.
pp. 1–5 = peræopods, 1st to 5th pairs.
up. 1–3 = uropods, 1st to 3rd pairs.
t. = telson.
pl^3. = 3rd segment of the pleon.
ur. = urus, last 3 abdominal segments.

PLATE I.

Fig. 1. *Parascelus parvus*, Claus.
,, 2. *Elsia indica*, Giles.
,, 3. *Ichnopus taurus*, Costa.
,, 4. *Socarnella bonnieri*, n. gen. et sp.
Fig. 5. *Vijaya tenuipes*, n. gen. et sp.
,, 6. *Lysianax cinghalensis*, Stebbing.
,, 7. ,, *cœlochir*, n. sp.
,, 9. *Urothoë spinidigitus*, n. sp.

PLATE II.

Fig. 10. *Platyischnopus herdmani*, n. sp.
,, 11. *Ampelisca tridens*, n. sp. (see also Pl. IV.).
Fig. 12. *Ampelisca scabripes*, n. sp.
,, 13. ,, *brachyceras*, n. sp.
Fig. 14. *Ampelisca cyclops*, n. sp.

PLATE III.

Fig. 15. *Ampelisca chevreuxi*, n. sp.
,, 16. *Gallea tecticauda*, n. gen. et sp. (see also Pl. VIII.).
Fig. 17. *Leucothoe hornelli*, n. sp.
,, 17a. ,, *stegoceras*, n. sp.
,, 18. *Anamixis stebbingi*, n. sp.
Fig. 19. *Stenothoe gallensis*, n. sp.

PLATE IV.

Fig. 8. *Tryphosa cucullata*, n. sp.
" 11. *Ampelisca tridens*, n. sp. (see also Pl. II.).
" 20. *Perioculodes serra*, n. sp.
" 21. *Tiron thompsoni*, n. sp.
" 22. *Eusiroides cæsaris*, Stebbing.
Fig. 23. *Eusiroides orchomenipes*, n. sp.
" 24. *Dexamine serraticrus*, n. sp.
" 25. *Tritæta antarctica*, Stebbing.
" 26. *Guernea lævis*, Chevreux.
" 27. *Hornellia incerta*, n. gen. et sp.
Fig. 28. *Melita anisochir* (Kröyer).

PLATE V.

Fig. 29. *Mæra othonoides*, n. sp.
" 30. " *rubro-maculata* (Stimpson).
" 31. " *tenella* (Dana).
" 32. " *scissimana* (Costa).
Fig. 33. *Mæra tenuicornis* (Dana).
" 34. *Elasmopus subcarinatus* (Haswell).
" 35. " *dubius*, n. sp.
" 36. " *spinimanus*, n. sp.

PLATE VI.

Fig. 38. *Parelasmopus suluensis* (Dana).
" 39. *Lembos podoceroides*, n. sp.
" 40. " *chelatus*, n. sp.
Fig. 41. *Gammaropsis zeylanicus*, n. sp.
" 42. *Cheiriphotis megacheles* (Giles).
" 43. *Photis longicaudata* (Sp. Bate).

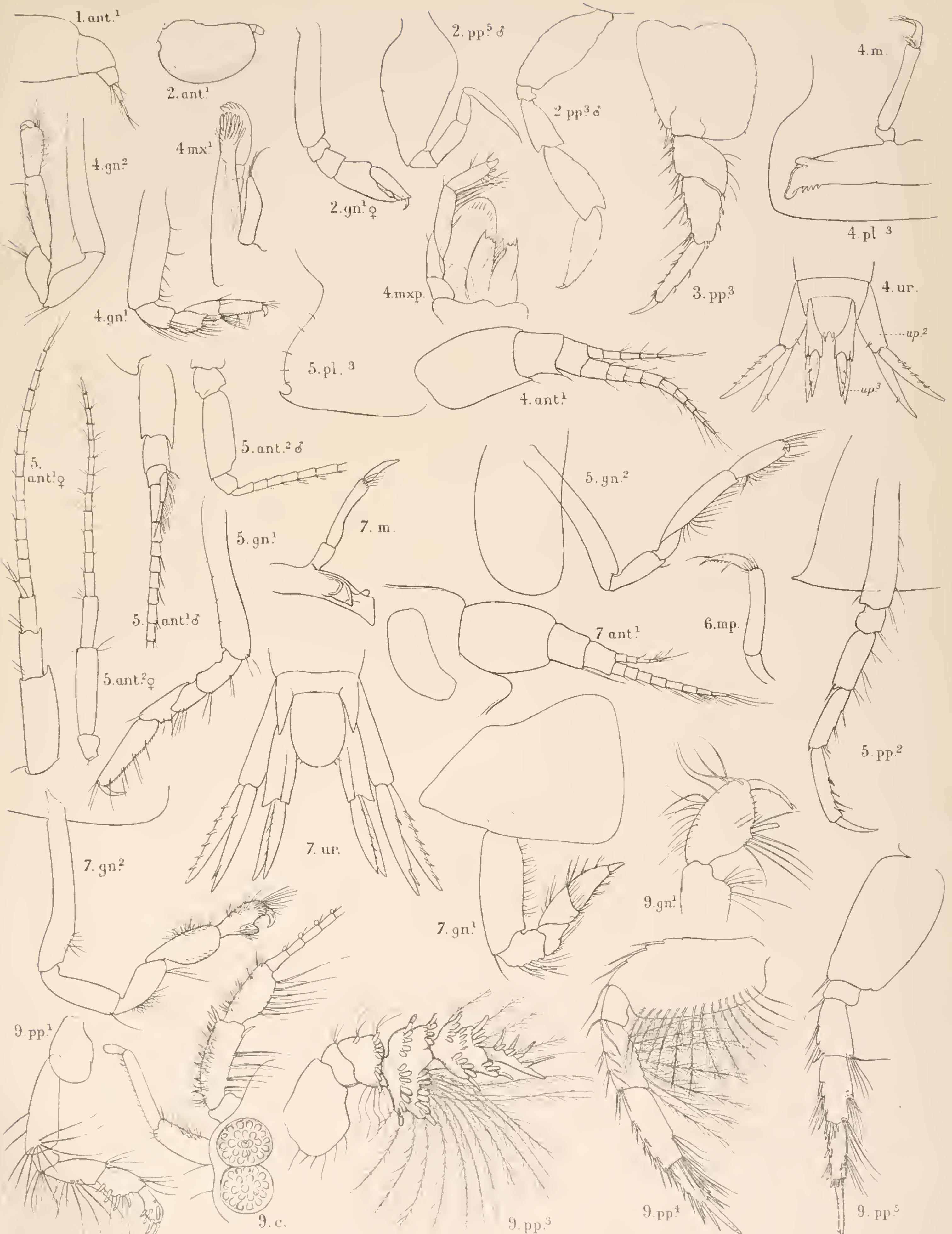
PLATE VII.

Fig. 44. *Photis longimanus*, n. sp.
" 45. " *nana*, n. sp.
" 46. *Amphithoe intermedia*, n. sp.
" 47. *Jassa falcata* (Mont.).
Fig. 48. *Erichthonius macrodactylus* (Dana).
" 49. *Siphonœcetes orientalis*, n. sp.
" 50. *Chevalia aviculæ*, n. gen. et sp. (see also Pl. VIII.).
Fig. 51. *Platophium læve* (Haswell).

PLATE VIII.

Fig. 16. *Gallea tecticauda*, n. gen. et sp. (see also Pl. III.).
" 37. *Elasmopus serrula*, n. sp.
Fig. 50. *Chevalia aviculæ*, n. gen. et sp. (see also Pl. VII.).
" 52. *Platophium synaptochir*, n. sp.
Fig. 53. *Platophium zeylanicum*, n. sp.

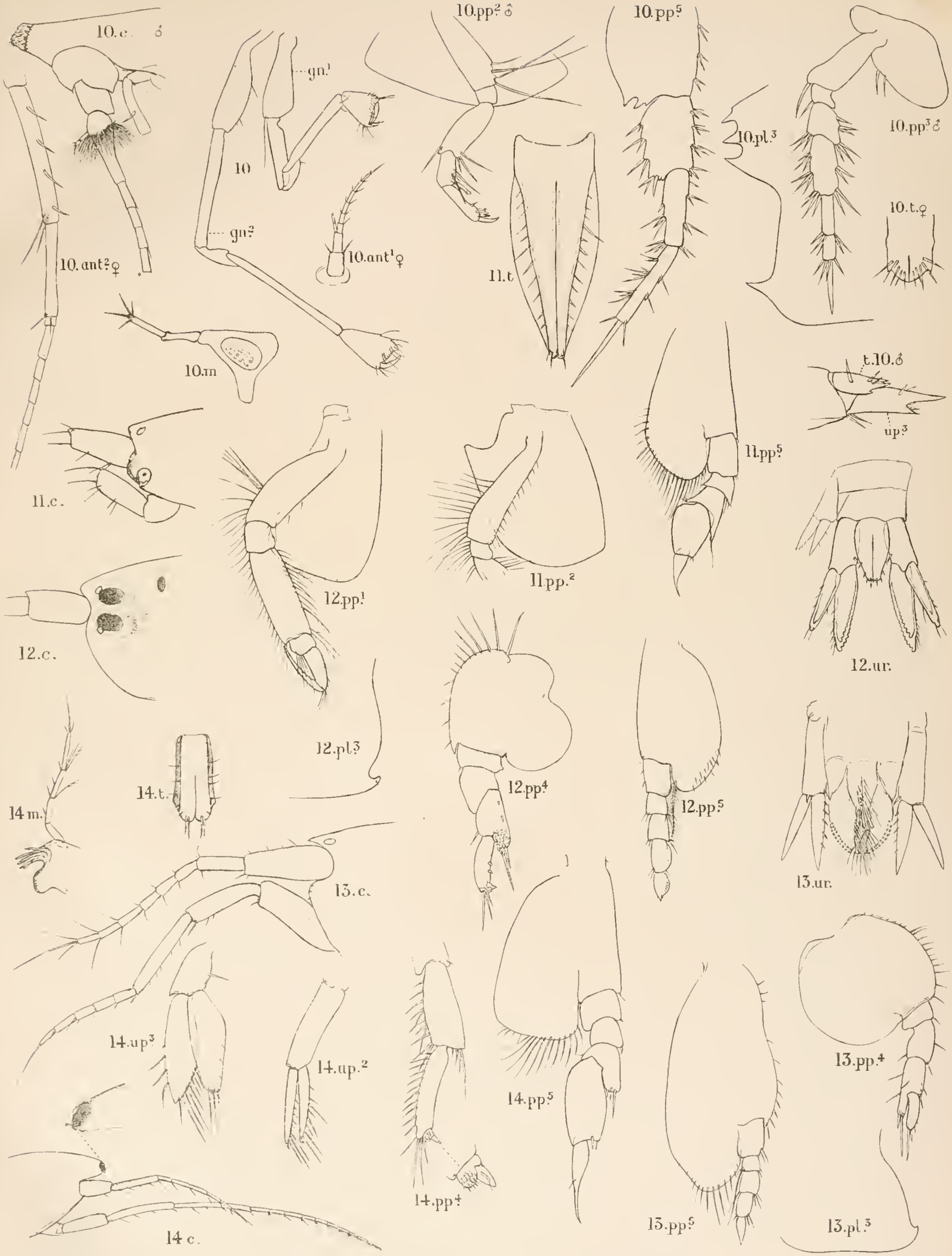
HARRISON AND SONS, PRINTERS IN ORDINARY TO HIS MAJESTY, ST. MARTIN'S LANE, LONDON.



A. Walker, P. Highley, del.

M'Farlane & Erskine Lith. Edinr.

1. Parascelus parvus. 2. Elsia indica. 3. Ichnopus taurus. 4. Socarnella bonnieri. 5. Vijaya tenuipes. 6. Lysianax cinghalensis. 7. Lysianax cœlochir. 8. (see Plate IV). 9. Urothoë spinidigitus.



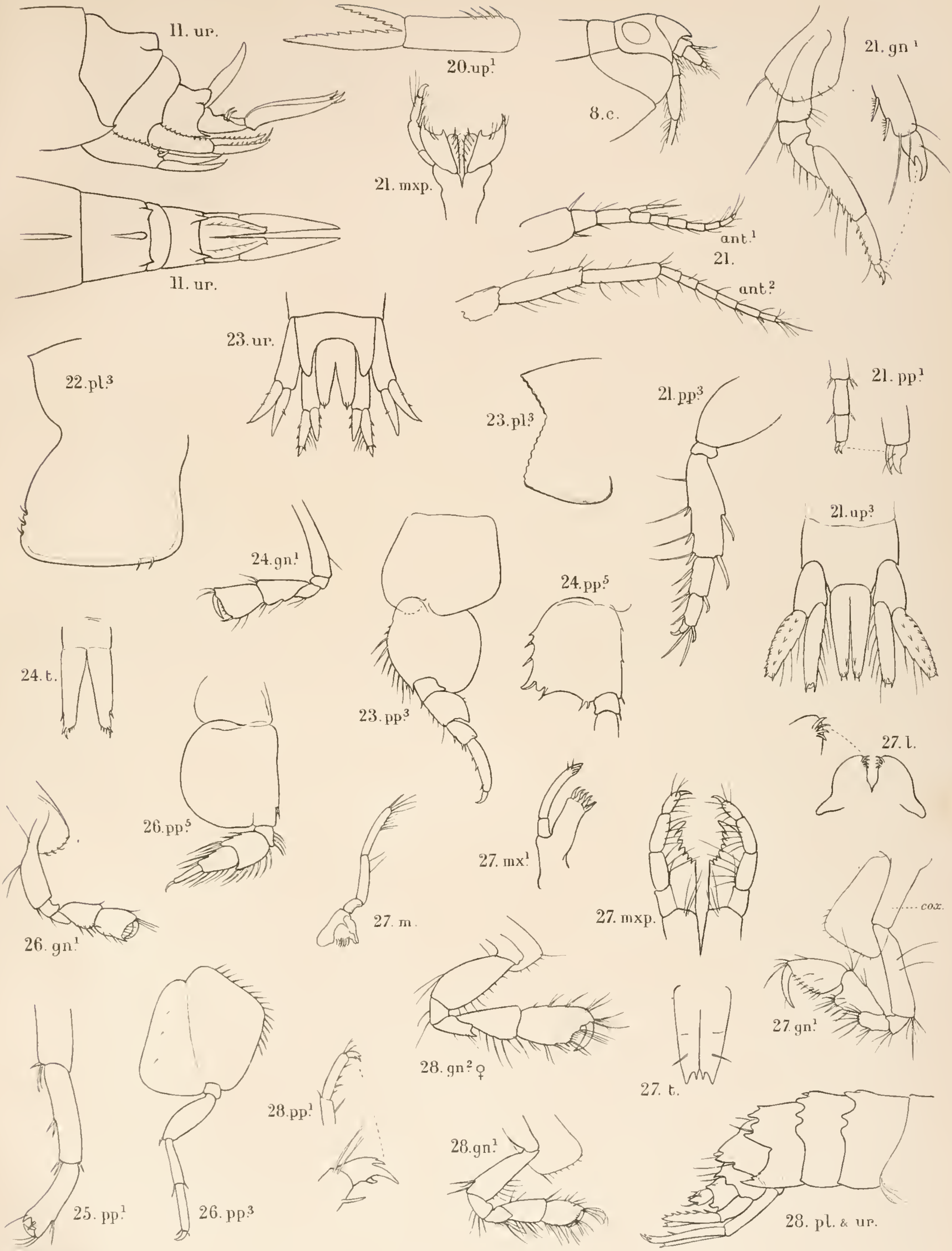
A. O. Walker, P. Highley, del. — McFarlane & Erskine, Lith. Edin.

10. PLATYISCHNOPUS HERDMANI. 11. AMPELISCA TRIDENS. 12. AMPELISCA SCABRIPES. 13. AMPELISCA BRACHYCERAS. 14. AMPELISCA CYCLOPS.

A. O. Walker, P. Highley, del.

M'Farlane & Erskine Lith. Edinr.

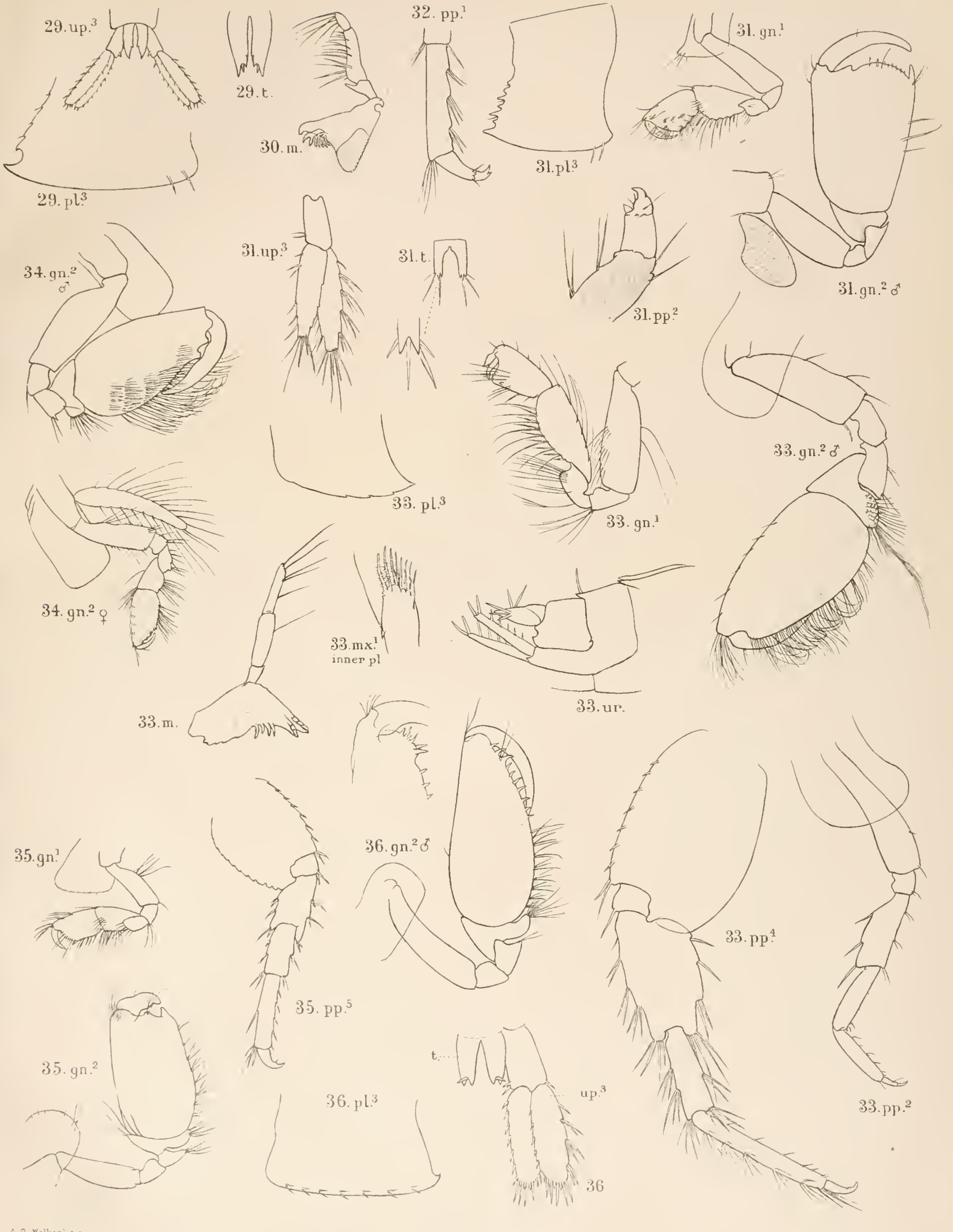
15. Ampelisca chevreuxi.
16. Gallea tecticauda.
17 Leucothoë hornelli.
17.A, L. stegoceras.
18. Anamixis stebbingi.
19. Stenothoë gallensis.



A. O. Walker } P. Highley } del

McFarlane & Erskine Lith Edin^r

8. Tryphosa cucullata. 20. Perioculodes serra. 22. Eusiroides cæsaris. 24. Dexamine serraticrus.
11. Ampelisca tridens. 21. Tiron thompsoni. 23. E. orchomenipes. 25. Tritæta antarctica.
26. Guernea lævis. 27. Hornellia incerta. 28. Melita anisochir.



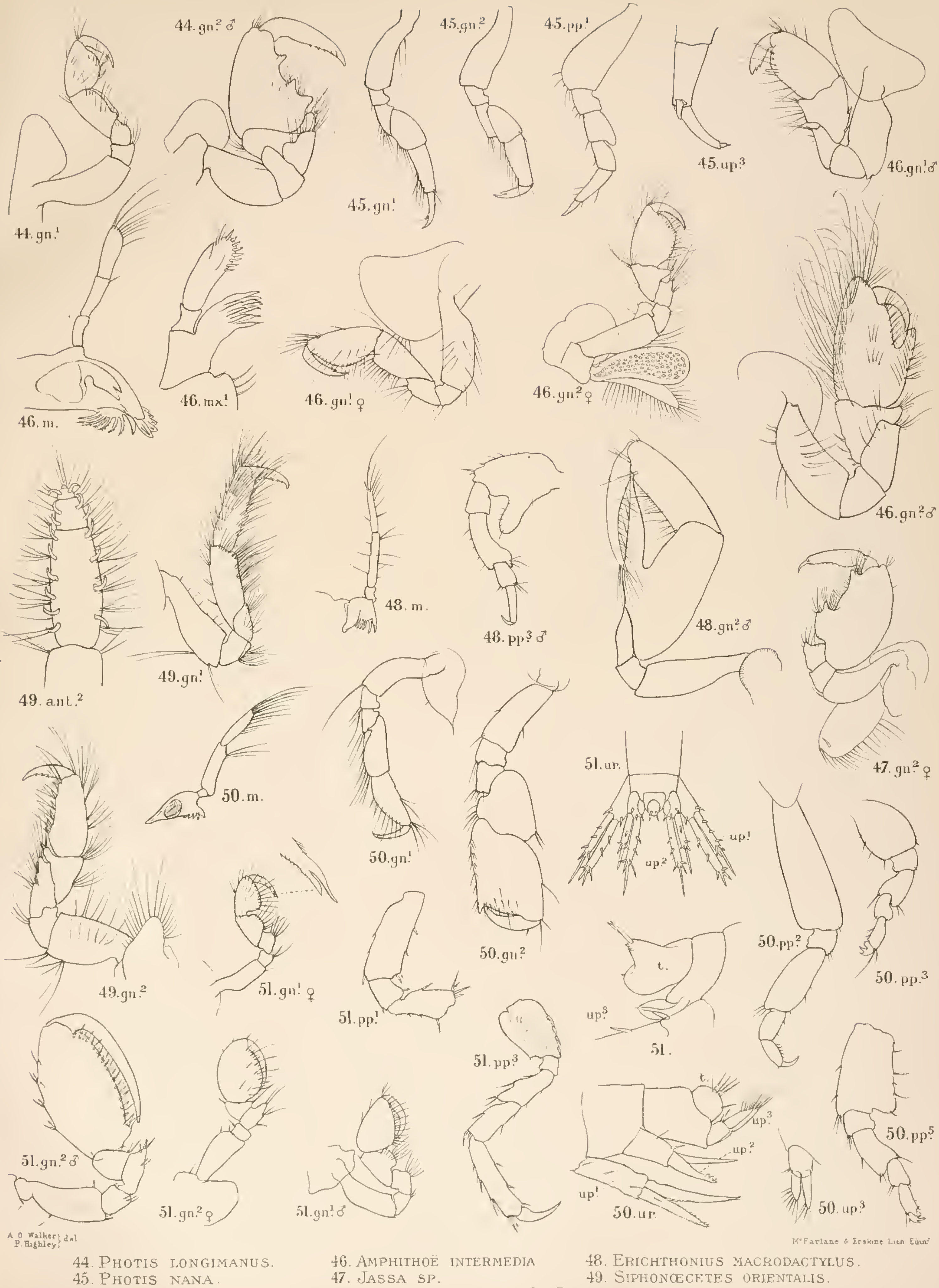
A. O. Walker / P. Highley del. M'Farlane & Erskine Lith. Edin'.

29. Mæra othonides. 31. Mæra tenella. 33. Mæra tenuicornis 35. Elasmopus dubius.
30. M. rubromaculata. 32. M. scissimana. 34. Elasmopus subcarinatus. 36. E. spinimanus.

A. O. Walker, P. Highley, del.

McFarlane & Erskine, Lith. Edin.

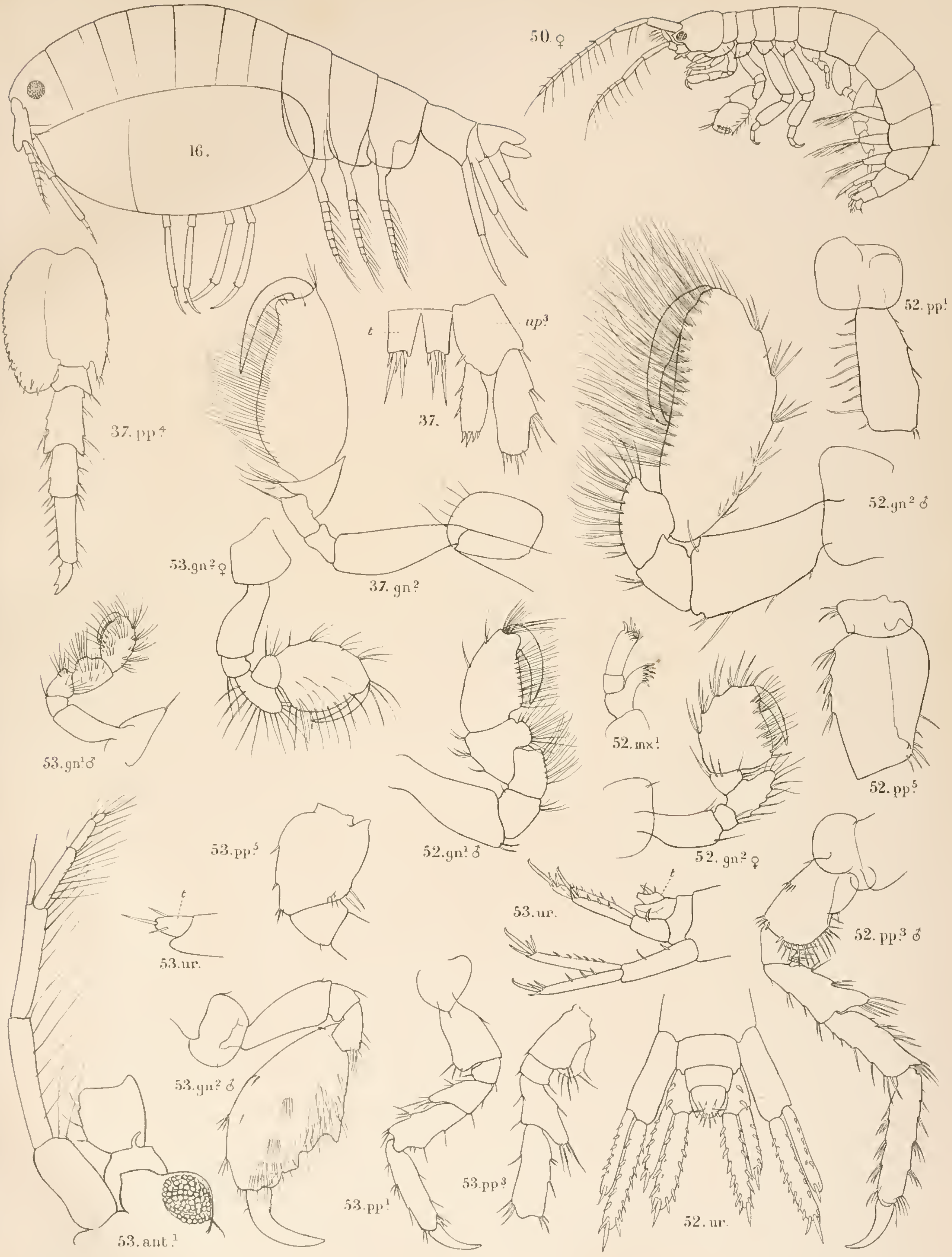
38. Parelasmopus suluensis.
39. Lembos podoceroides.
40. Lembos chelatus.
41. Gammaropsis zeylanicus.
42. Cheiriphotis megacheles.
43. Photis longicaudata.



A. O. Walker, P. Highley, del.

McFarlane & Erskine Lith. Edin.

44. Photis longimanus. 45. Photis nana. 46. Amphithoë intermedia. 47. Jassa sp. 48. Erichthonius macrodactylus. 49. Siphonœcetes orientalis. 50. Chevalia aviculæ. 51. Platophium læve.



A. O. Walker, P. Rigbley del.

M'Farlane & Erskine Lith. Edin.

16. Gallea tecticauda. 37. Elasmopus serrula. 50. Chevalia aviculæ.
52. Platophium synaptochir. 53. Platophium zeylanicum.